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U. S. DEPARTMENT OF AGRICULTURE.

OFFICE OF EXPERIMENT STATIONS.

W. O. ATWATER, DIRECTOR.

EXPERIMENT STATION BULLETIN No. 2.

DIGEST
OF THE
ANNUAL REPORTS
OF THE
AGRICULTURAL EXPERIMENT STATIONS
IN THE
UNITED STATES
FOR
1888.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
Washington, D. C., May 18, 1891.

SIR: I have the honor to transmit herewith, for publication, Experiment Station Bulletin No. 2, Part II, of this Office, containing a digest of such of the annual reports of the Stations for 1888 as were not included in Part I of this bulletin. The delay in the final preparation of this portion of the digest of reports for 1888 is explained by the fact that the last of the reports for that year was not received at this Office until March 16, 1891.

Respectfully,

W. O. ATWATER,
Director.

Hon. J. M. RUSK,
Secretary of Agriculture.

DIGEST OF THE ANNUAL REPORTS OF THE AGRICULTURAL EXPERIMENT STATIONS IN THE UNITED STATES FOR 1888.

KANSAS.

Kansas Agricultural Experiment Station.

Department of Kansas State Agricultural College.

Location, Manhattan. Director, E. M. Shelton, M. S.

FIRST ANNUAL REPORT, 1888.

Report of Station Council (pp. 1–6).—The act of Congress of March 2, 1887, was assented to by the legislature of the State March 3, 1887, and the control of the Station to be organized under that act was given to the Board of Regents of the Kansas State Agricultural College. The Station was organized February 8, 1888, and it was ordered by the Board of Regents—

> (1) That the general executive management of the Station shall be under the control of a council, consisting of the president of the college, and the professors of agriculture, horticulture and entomology, chemistry, botany, and veterinary science; (2) that the president of the college shall be *ex officio* chairman of the council, and the professor of agriculture *ex officio* director and general superintendent in executing the plans of the council; and (3) that each member of the council shall have full control of work assigned to his department, choosing his own assistants, subject to ratification by the council.

Among the general rules adopted by the council are the following:

> (1) All experimental undertakings in any department must first receive the sanction of the council; and (2) all wants in any department not provided for by direct action of the board may only be supplied by purchases authorized by the council.

During 1888 the Station issued five bulletins as follows: No. 1, April, Organization, Equipment, and Aims of the Station. No. 2, April, Cultivated Grasses and Clovers in Kansas; Fourteen Years Experience at the College Farm. No. 3, June, Observations on Two Insect Pests, the Apple-Twig Borer (*Amphicerus bicaudatus*, Say) and a New Apple Insect (*Graptodera foliacea*). No. 4, September, Experiments with Wheat. No. 5, December, Comparison of Varieties of Sorghum and Preliminary Report on Sorghum Blight.

The printing of the bulletins was done by the printing department of the college. These bulletins have been issued in editions of 7,000 copies, except No. 2, of which 9,000 copies were printed. The mailing list of the Station numbers over 5,000 addresses and is steadily growing.

The council points with satisfaction to the fact that a very large proportion of the work of the Station is done by students and graduates of the college. The college supplied, without delay, the trained minds and hands needed in the work of investigation peculiar to the Experiment Station.

REPORT OF FARM DEPARTMENT, E. M. SHELTON, M. S., H. M. COTTRELL, M. S., AND W. SHELTON (pp. 9–116), (illustrated).—The thought underlying the work of this department has been to apply accurate tests, as far as possible, to all the operations of Kansas farming as practiced in this locality. To this end experiments were begun in different lines as follows:

Corn.—Methods of planting, cultivating and harvesting.
Wheat.—Varieties and methods of cultivation.
Grasses and forage plants.
Sorghum. —Varieties and methods of cultivation for forage and sugar.
Oats.—Varieties and methods of cultivation. [Ruined by chinch-bugs.]
Experiments with methods of preserving farm-yard manure.
Experiments in feeding steers to test different foods.
Experiments in feeding pigs with different foods.
Experiments to show the influence of different foods in milk and butter production.
Experiments with silos and in the making of ensilage.

Waste of manure in summering it in the yard (pp. 10–14).—The object of this experiment was to get light on the question: How much manure is wasted by keeping it in the yard through the "torrid summers" of this region? "The all too popular method over the West is to leave the manure in the corral until it has accumulated in such masses that either the corral must be abandoned or the manure hauled somewhere." But as the value of barn-yard manure comes to be better appreciated it is ordinarily preserved either by piling it against a building or fence, or by allowing it to accumulate evenly over the yard, where it is trodden compact by the animals. In some cases gypsum is sprinkled liberally over the manure as it accumulates, on the supposition that gypsum prevents decomposition.

To test these three methods of preserving manures side by side with the familiar practice of placing the manure pile on a slope favorable to the leaching process, four small inclosures, each about 10 feet square, with corner posts, and boarded up to the height of 3 feet, were made upon a level tract of ground neai the barn-yard. From three of these (yards 1, 2, and 3) the surface earth, to the depth of about 1 foot, was removed over the inclosed area. They were then floored with loose boards, for convenience in shoveling the manure from the yard when the time of emptying should come. Yard 4 was located on the surface of a gentle and smooth slope, which greatly favored the passage of surface water to a neighboring brook. The manure employed in this experiment was mostly from stable-fed cattle. It was very rich, and uniform in texture and quality throughout. In filling, the yards received one load at a time in regular order, beginning with yard No. 1. In this way the work of filling the yards was completed in the case of each practically at the same time. * * *

The treatment given the contents of each yard is concisely stated as follows:

Yard No. 1.—Contents 5 tons of manure thrown in loosely.

Yard No. 2.—Contents 4$\frac{3}{4}$ tons of manure loosely piled, intimately mixed with 500 pounds of gypsum.

Yard No. 3.—Contents 5 tons of manure firmly packed in filling.

Yard No. 4.—Contents 5 tons of manure loosely piled, with excellent drainage at bottom.

October 31 the manure was taken from the yards and weighed. The gross weight of the manure and the per cent of water, dry substance, nitrogen of dry substance, and pounds of nitrogen, as determined by the Station chemist April 11 and October 31, with the gains or losses in 203 days, are given in tables. The following summary shows the losses in gross weight of manure, dry substance, and nitrogen, expressed in percentages of the weights at the beginning of the test:

Losses in manure from April 1 *to October* 1 *under different treatments.*

Yard No.	Treatment.	Gross weight.	Dry substance.	Nitrogen.
		P. ct.	*P. ct.*	*P. ct.*
1	Manure piled loosely	48	55	38
2	Manure piled loosely (with 5.2 per cent of gypsum)	43	31	37
3	Manure packed solid	38	42	37
4	Manure piled loosely (with free leaching)	53	52	39

The loss of nitrogen was nearly the same in all the yards, the variation being so slight as to amount to nothing.

On the other hand the shrinkage of the gross manure and of its dry substance varied very greatly in the different yards, the loss of manure in its ordinary condition being least where it was packed solid, while the loss of dry substance of manure was least where gypsum was mixed with the manure. The packing seems to have been influential alone in checking the escape of water. * * *

The moral which the experiment plainly emphasizes is, that farm-yard manures must be hauled to the field in the spring, otherwise the loss of manure is sure to be very great, the waste in the course of 6 months amounting to fully one-half the gross manure and nearly 40 per cent of the nitrogen which it contained.

Experiments in the corn field (pp. 14–54).

As a foundation for more scientific work, to be undertaken in coming years, it has seemed to me of first importance that the work of the farm should in the outset be largely devoted to securing accurate data regarding all local farm crops and methods. Without an accurate knowledge of the gains and losses of common practices it is certain to be difficult, if not impossible, in many cases, to make a direct application of the lessons of science. How shall we speak certainly of the needs of agriculture, and how shall we apply the remedy if we are ignorant of its present condition and the possibilities that lie concealed beneath the rubbish of existing methods?

With the object of learning more of the relative values of some of the common methods by which the corn crop is "made," experiments in the cultivation and management of the great Western staple have been carried out at this Station during the cropping season of 1888.

Inaccuracy in planting and consequent loss of crop (pp. 15–19).—Early in May a field of 12 acres was planted to corn with a standard drill. "The soil was in excellent tilth, the ground having been plowed the previous fall and again just before planting." The corn made what seemed to practical men an excellent stand, but a close examination revealed great irregularity in the spaces occupied by the corn plants, due undoubtedly to the faulty action of the drill. "To test this variableness in the planting of the different rows, 100 rows of 150 feet on the two opposite sides of the field were measured off for examination. As soon as the plants had seemingly passed the ordinary exigencies ot the early growing state (July 7) and had secured a permanent hold upon the soil, the stalks in each row were counted."

It was found that the number of plants in the different rows varied from 62 to 143. To study the meaning of this variation 75 rows, located where the soil was most uniform, were further examined. The yield of these rows was also husked and weighed during the first week of October. The number of stalks, pounds of corn, and estimated yield per acre in bushels of 75 pounds for each row are given in a table. In a second table the rows are grouped according to the number of stalks in 150 feet, the groups having 75, 84–89, 91–95, and so on, to 126–129 and 138–143 stalks in the row. With 75 stalks to the row, the distances from plant to plant averaged about 24 inches. With 138–143 stalks to the row the average distance was about 12 inches. The yields of the single rows varied from 24½ to 27⅓ bushels per acre. Grouped by the number of stalks to the row, the yield with 75 stalks to the row and averaging 24 inches apart, was 29.7 bushels per acre. As the number of stalks increased the yield increased, until in the group with stalks averaging 15 inches apart it was 58 bushels, and then fell off until in the group with stalks averaging 12 inches apart it was 45.1 bushels.

We must also remember that the seed, whether thickly or sparingly distributed, was irregularly strewn, a crowded area being succeeded by blank spaces, large or small, in perhaps every row, so that even where the correct or least correct amount of seed was used the complete influence of the particular seeding is not shown. The figures show that with the variety of corn here employed (a medium large dent) the largest yield was obtained when the kernels of seed were placed 14 to 16 inches apart in the rows—the drill was set to deposit kernels 16 inches apart—and slight deviations from this, whether in the direction of increased or diminished seeding, were promptly followed by a diminished yield.

Few will doubt that facts similar to the above can be furnished by every corn field in Kansas, and for that matter the entire West. It seems clear, too, that the maximum yield shown in the summary (57.99 bushels) could, with proper planting, have been made the average yield of the entire field, and this might have been raised with as small cost in labor as was expended for the lowest yield (29.7 bushels) of the summary.

That we get from our corn fields nothing like what they ought to yield us is the plain corollary of the above facts. If the single operation of planting, important as it is, affects the crop so materially, what may we expect when to faulty seeding is added insufficient plowing and imperfect cultivation ?

Experiments with varieties (pp. 19–23).—Thirty varieties of corn were tested on the college farm in 1888. Notes on each variety are given in tabular form. Illustrations of the ears from a few varieties of flint and dent corn are given in two plates.

Among the dent varieties the most valuable, basing judgment on quality of grain, productiveness, and hardiness, and naming sorts in the order of merit, were: Yellow Mammoth, Leaming, Pride of the North, Murdock's, Farmer's Favorite Golden Dent, St. Charles, Queen of the Prairie, Early Yellow Hathaway, and White Giant Normandy. Judging by the same standards, the most valuable of the early-maturing flint varieties were Early Red Blazed, Longfellow, and Angel of Midnight.

Planting early varieties (pp. 23–27).—Under this head some general facts relating to corn culture in Kansas are stated.

We have here almost universally the rich, deep, friable soil which the experience of all corn-growing communities has shown to be necessary to the perfect growth of the great staple. Moreover, here are the fervent summer heats and great length of growing season, so well calculated to bring the corn plant in all its parts, leaf, stalk, and ear, to the greatest perfection. As a result of these natural influences the corn plant in Kansas assumes the largest proportions; the stalks are coarse and very tall; the leaves are broad and long, if not numerous; while the ear is large and lifted far above ground, often above the tassels of the small-growing sorts, as was shown in our experiments. Small-growing, dwarfish corn is never seen in Kansas except in cases where the seed used or its immediate ancestors has been introduced from the North; and even these small-growing foreign sorts when grown for a series of years in Kansas, tend rapidly toward the normal type. A variety of King Philip corn grown on the college farm since 1876 and in this vicinity since 1872 or 1873, and kept pure meanwhile, is no longer a flint corn, but in size and habit of growth it more nearly resembles a medium dent sort than the familiar New England variety from which it is descended.

All this shows clearly to my mind that those natural forces which have chiefly to do with "making" the corn crop in Kansas all favor the plant of largest growth. As to avoiding the hot winds, these are possible during every summer month, and our table shows that not one of the flint sorts grown by us last season would ordinarily escape them. Indeed it is more than possible that the early-maturing sorts would suffer most from this cause, as July is (to the corn crop) the critical month. So far as climate goes, these sorts would be in that fully developed state in which the plant makes largest demands upon soil and climate, and suffers most from any failure to supply them.

Those who advocate the general culture, as a field crop, of the small flint sorts evidently are unacquainted with the behavior of these sorts as grown in Kansas. Most of the small-growing varieties can not be relied on to yield much more than one-half of what constitutes a fair crop of the familiar dent corn, and our experience with these sorts, covering many years, agrees with the facts as stated above, where it is shown that the yield of the small-growing sorts was often less than one-half of the yield of the dent varieties growing in contiguous plats. The ears of the early corn, too, were poorly filled and very chaffy. There were large bare spaces of cob on nearly every ear. The illustration, which represents six fair, average ears of as many different sorts, will make clear this defect of the early varieties. The flint sorts suffered, too, beyond anything known heretofore with familiar varieties, from the attacks of the corn worm (*Heliothis armigera*), which has rarely proved a serious pest in this section except with very late sorts.

Taking the years together, the coarse (not necessarily the coarsest) or freest-growing varieties will prove the largest yielding, and the safest and the most profitable for general cultivation. For all this it is wise, I am firmly convinced, to plant a portion of the corn ground each season to the medium or small-growing varieties. These sorts afford both grain and fodder far in advance of the coarser-growing kinds, and it will occasionally happen that the smaller sorts make a crop when all others fail. We have for many years grown a modified King Philip with satisfaction and profit. It is ready for the harvest 2 or 3 weeks earlier than any of the commoner varieties; it yields well both of corn and fodder; but it must be admitted that it is very often caught by the hot winds.

Treatment of growing corn (pp. 27–32).—"The special object of the experiment was to study the effect of removing the tassels or male flowers from the stalks as fast as they appeared; to note the influence of the lateral shoots (suckers) upon the crop; and the effect of removing, at the earliest ripening of the ears, all that portion of the stalk above the ear (topping)."

Thirty-one rows, each 270 feet in length, were taken in a portion of a field where the soil was very uniform. It was planned to have only 160 bearing plants in each row, but in the case of 9 rows this was found impossible.

The plan of the experiment is clearly shown in the table, together with a full statement of results, including the yield of sound ears closely culled and "nubbins," and the calculated yield per acre, while a compact summary gives the grouping of the specially treated rows in each case. A word of explanation may seem needed regarding the "nothing" rows here used as a standard of comparison: These rows simply received no manipulation or special treatment whatever.

The tassels were removed as soon as they appeared—between July 9 and 24, the suckers June 28, while the topping was done much later—July 30 and 31. The variety of corn here used was a medium-sized yellow dent. Here, as elsewhere in the experiments with corn, the bushel refers to 75 pounds of ears.

Summary.

No. of plat [row].	Treatment.	Yield of plat.		Yield per acre.			Yield per, plant, corn.
		Sound ears.	Nubbins.	Sound ears.	Nubbins.	Total.	
		Pounds.	*Pounds.*	*Bushels.*	*Bushels.*	*Bushels.*	*Pounds.*
1, 5, 9, 13, 17, 21, 25, 30	Suckered	87.62	9.12	53.80	5.60	59.40	.61
2, 6, 10, 14, 18, 22, 26, 29	Nothing adjacent, suckered	88.57	14.28	54.38	8.76	63.14	.67
3, 7, 11, 15, 19, 23, 27, 31	Tasseled	72.87	21.00	44.74	12.89	57.63	.61
2, 6, 10, 14, 18, 22, 26, 29	Nothing adjacent, tasseled	88.57	14.28	54.38	8.76	63.14	.67
4, 8, 12, 16, 20, 24, 28	Topped	81.71	15.71	50.16	9.64	59.80	.61

An examination of the table reveals some interesting and suggestive facts. The removal of the suckers was a positive loss to the crop in every respect save one. The yield per acre of the suckered rows was 5 bushels less than that obtained in the adjacent "nothing" rows, and there was a corresponding loss in the yield of each plant. This result agrees substantially with the facts shown in an extended experiment made upon the college farm in 1877 to test the same point. The quality of the corn yielded in the suckered rows was markedly superior to that obtained from the other specially treated areas. It was better than that obtained from the "nothing" rows, and greatly superior to the product of the tasseled and topped rows, which was frequently very poor. The reason for this superiority of the corn obtained from the suckered rows is easily explained by the absence of the lateral shoots and the consequent small ears which they bear.

The removal of the tassels was certainly no benefit to the crop, and almost certainly an injury. Besides the diminished yield as compared with the "nothing" areas, amounting to 5½ bushels per acre, there was a considerable increase in the amount of poor corn or nubbins, so that the average as to quality of grain was very low.

All that has been said of the effects of removing the tassels from corn might be repeated truthfully enough of the effects of removing the entire top from growing corn, except that the quality of the corn produced by the topped rows was greatly inferior to that had from the rows which had been tasseled.

The lesson of this experiment plainly seems to be that all manipulation, all cutting and hacking of that portion of the corn plant above ground, is worse than time wasted; that, in short, the corn plant does best when allowed to develop without manipulation or interference.

Treatment of corn ground.—Listing (pp. 32–37).

During the past 12 years our ideas and practices relative to the treatment of corn ground in Kansas have undergone a nearly complete revolution. A dozen years ago corn land was universally plowed and the seed was planted in the fashion known familiarly as "check-rowing." At the present time nearly or quite three-fourths of Kansas corn is raised by the method known as "listing," which I may say in explanation, consists of drilling the seed in the bottoms of deep furrows struck at the usual intervals in ground not otherwise plowed. Even in those sections where the old practice of plowing prevails the seed is nearly as often drilled as check-rowed.

Practical men make many claims for the new plan of corn culture, most of which, it must be confessed, seem to be well supported by the facts. It is claimed that listed corn endures dry weather much better than the surface-planted; that it gives an increased yield; and this especially, that the labor of growing a crop of corn is reduced one-quarter to one-third by the new method. * * *

To test the method of listing as nearly as possible in every phase, the experiment hereinafter detailed was planned and carried out during the last season. Sixteen plats were laid off in field E, and these were grouped in four series, each of which contained two listed and two surface plats. The two listed plats were planted, one by the method of hills, the other in drills, as were the two surface-planted plats. Each plat conisted of eight rows of corn, and each row occupied space measuring 162 by 3½ feet. The table shows the arrangement of the differently treated plats, as well as the yield of each in corn and fodder.

In order to remove every cause of variation except the particular treatment given in planting, the number of plants grown in every row was made the same throughout the entire experiment. The drilled plats were planted with a view to securing a stand of one plant to every 16 inches; and plants in the hilled rows, whether "listed" or planted on the surface, were thinned out to a number exactly equal to that of the drilled rows. In this way, and only in this way, it seems to me, could we get a direct and unequivocal answer to the question: Will listing give a larger yield than surface cultivation, and if so, is it best to plant the furrows in hills or with the drill?

The soil of the field used in this experiment was a deep loam of extraordinary fertility. The corn employed was a yellow dent of medium growth. The planting was done on May 5, and the subsequent treatment given the plats amounted to good, "clean cultivation," and not much more. * * *

Summary.

No. of plat.	Treatment.	Yield of plat.		Yield per acre.		Gain, listed over surface-planted.	
		Corn.	Fodder.	Corn.	Fodder.	Corn.	Fodder,
		Pounds.	*Pounds.*	*Bushels.*	*Tons.*	*Bushels.*	*Tons.*
2, 5, 7, 11, and 15	Listed drills	364	478	46. 61	2. 29	6. 07	0. 28
3, 6, 9, and 13	Surface drills	316	420	40. 54	2. 01	....	....
8, 12, and 16	Listed hills	359	479	45. 98	2. 30	5. 52	0. 49
1, 4, 10, and 14	Surface check-rowed	315	370	40. 46	1. 81	....	....

There can be no doubt that the listing in itself was a real benefit to the crop. * * * It is an interesting fact, too, that the drilled plats show small advantage, other things equal, over the plats that were planted in hills.

The cultivation of growing corn (pp. 37–42).

The question, How much cultivation is necessary to the full development of the corn plant? is the one of chief interest to the growers of the great staple in the West. * * *

Sixteen plats, continuous with those listed and surface-planted, were arranged with the object of testing the different methods of cultivating the growing crop. Each plat consisted of four rows of corn, and each row occupied 162 by 3½ feet of space. The plats were all plowed, harrowed, and otherwise prepared for planting on the same day, and the planting, done with a drill on the surface of the ground, was completed on May 5. After the corn plants had become firmly rooted the plats were thinned out, leaving a uniform number of plants in the rows of the entire series. * * * By "slight cultivation" was originally intended no cultivation at all. On account of the multitude of small weeds which sprung up, keeping pace with the corn in its early growth, it was found necessary to pass the cultivator back and forth lightly once in each row. * * *

The plats receiving surface culture were cultivated wholly with a new surface-acting machine known as the Tower surface cultivator. * * *

The plats of "ordinary cultivation" received two very thorough dressings, on June 7 and 13, with the ordinary two-horse walking cultivator.

The plats receiving excessive cultivation were thoroughly tilled on June 7 and 13, and July 7. In this operation, the ordinary two-horse walking cultivator was used. It was run twice in a row at each operation, and was held to cut as deep and as close to the rows of corn as possible, with the object of doing all the good or harm the machine was capable of.

A table gives the details of the experiment.

Summary.

No. of plat.	Treatment.	Yield of plat.			Yield per acre.			
		Sound ears.	Nubbins.	Fodder.	Sound ears.	Nubbins.	Total corn.	Fodder.
		Pounds.	*Pounds.*	*Pounds.*	*Bushels.*	*Bushels.*	*Bushels.*	*Tons.*
1, 5, 9, and 13....	Slight cultivation........	147	66	145	37.63	16.96	54.59	1.39
2, 6, 10, and 14....	Ordinary cultivation....	187	57	171	48.09	14.75	62.84	1.64
3, 7, 11, and 15....	Surface cultivation.....	177	60	186	45.31	15.42	60.73	1.78
4, 8, 12, and 16....	Excessive cultivation ..	163	64	187	41.76	16.41	58.17	1.80

This experiment is not likely to satisfy the advocates of either of the four methods here tested. But while far from decisive, the results here detailed are almost exactly in line with accurately conducted experiments made here before, and with years of general experience had at the college farm. The moderate cultivation, which kept the ground free from weeds and prevented it from "baking," upon rich soil and during a favorable season supplied every requirement of the corn plant. Had the land used in this experiment been of poor quality and the season a bad one, we might have expected very different results. In other words, cultivation may be made to help a bad soil or season, but when both are favorable, tillage sufficient to keep the ground free of weed pests and moderately porous is emphatically sufficient.

Harvesting for fodder and corn (pp. 42–54).

This history of experiments with corn is appropriately enough concluded with a statement of facts gathered during the season, bearing upon the time of harvesting the crop, or rather the condition as to maturity, of the crop as affecting both fodder and corn.

Professor Sanborn has shown (see Bulletin No. 22, Missouri Agricultural College) that when flint and dent varieties are cut with the grain in the same condition of under-ripeness, the shrinkage in the grain of the flint sorts is much less than with the dent varieties.

To test this and related matters, three varieties of most pronounced flint corn and three of dent were made the subjects of careful experiment. In nearly every case one hundred plants of several sorts were used—in three instances two hundred plants were employed and in three other cases a few less than one hundred; but in all these exceptional cases calculations were made for one hundred plants as indicated in the table. The flint and dent varieties were both cut when in the same condition of ripeness. There were chances for mistakes here, it must be admitted. Corn is in the "milk" state, for example, several days, often weeks, and it is far from an easy task to decide when the two classes were in exactly this "same condition" of milkiness. There was much less trouble in reaching uniformity in doughiness, and none whatever in grouping the sorts in a common "ripe" state. The hundred plants were cut at the dates given, and at once, with accompanying suckers, were weighed; then tied in bundles; and on the day following shocked. A month or more later, when thoroughly cured and dry, the corn was husked and stored away for more perfect drying and the fodder weighed. The table gives in very full detail the facts of this experiment. * * *

The gains and losses of the different cuttings are plainly seen in a comparison of percentages as shown in the following statements:

Varieties.	Per cent of shrinkage from green to dry.	Per cent of sound ears.	Per cent of cob to corn.
Average of flints—first cutting	77	18	22
Average of dents—first cutting	71	3	18
Average of flints—second cutting	73	53	20
Average of dents—second cutting	55	55	17
Average of flints—third cutting	57	47	20
Average of dents—third cutting	44	82	14

The plain facts of the experiment are, leaving out of account the question of quality, that the dent varieties are the most profitable sorts for cultivation, even where the object is fodder; and where there is a double purpose—fodder and corn—the dent varieties, when cut as the corn begins to harden, have greatly the advantage in the quantity of fodder, in the amount of corn which it bears, and in the quality of corn as shown by the amount of sound ears and the proportion of cob.

Professor Sanborn's suggestion, that the flint varieties will bear earlier cutting than the dent, seems to be supported by the facts here presented. The failure of the flints to keep even with the dents when cut in the dough state and when ripe was clearly due to their intrinsic worthlessness for our soil and climate. They seemed out of harmony with their environment and in process of naturalization, while the dents from the start grew with a robustness that told plainly of their suitableness to the surroundings. * * *

To still further test the question as to the best time to cut standing corn with the view to securing the largest yield of corn and fodder, without much reference to varieties, a series of careful cuttings, and afterwards accurate weighings, was made in field E. Here rows of corn exactly equal as to length, and made by thinning exactly alike as to number of plants in a row, were measured off on opposite sides of the field. At one side, occupied by a yellow medium dent, four cuttings were made when the corn was in as many different degrees of ripeness. On the opposite sides of the field, occupied by the King Philip sort (a greatly modified flint), five different cuttings were made of corn in as many different stages of ripeness, as explained further on. * * *

The plan was to have adjoining rows (or double rows) cut when the corn was in very different degrees of ripeness, so that any difference in the yield of the different rows would clearly be due to different times of cutting and not to differences in soil. * * *

First cutting, August 8.—Corn in "milk" state.
Second cutting, August 15.—Corn in "dough" state.
Third cutting, August 20.—Corn in hard "dough" state.
Fourth cutting, August 14 (King Philip).—Corn glazed and firm; September 4 (yellow dent).—Corn hard, stalks drying up.
Fifth cutting, September 4 (King Philip).—Corn hard, stalks drying up.

The corn was shocked as fast as it was cut and remained undisturbed until it was thoroughly dry, when (October 13) it was carefully husked, and after a few days' exposure to the sun corn and stalks were weighed, with the results as stated in the table. * * *

Summary.

No. of double rows used.	When cut.	Condition of grain.	Average yield dry corn.		Average yield dry fodder.	
			Per double row.	Per acre.	Per double row.	Per acre.
			Pounds.	*Bushels.*	*Pounds.*	*Tons.*
5	Aug. 8	Milk	30	15.36	95	1.82
4	Aug. 15	Dough	55	28.16	100	1.92
4	Aug. 20	Hard dough	62	31.74	106	2.03
12	Sept. 4	Hard; stalks drying	77	39.42	110	2.11

Summary for King Philip (modified flint).

No. of rows used.	When cut.	Condition of grain.	Average yield dry corn.		Average yield dry fodder.	
			Per row.	Per acre.	Per row.	Per acre.
			Pounds.	*Bushels.*	*Pounds.*	*Tons.*
10	Aug. 8	Milk	29	29.69	53	2.03
10	Aug. 15	Dough	40	40.96	51	1.95
9	Aug. 20	Hard dough	48	49.15	57	2.18
9	Aug. 24	Glazed, firm	52	53.24	52	1.99
10	Sept. 4	Hard, stalks drying	60	61.44	56	2.15

The facts, as shown in the original table, support with almost complete unanimity the conclusions reached in the summary. We find, for example, in nearly every case, that adjacent rows, cut at intervals of 7 to 20 days, show variations, with only two or three exceptions, in seventy-odd cases almost exactly proportionate to the difference in the time of cutting, the largest yield of the best quality of corn going with the row cut latest. Indeed we are plainly taught here that corn continues to improve in weight until the very last—after the blades of the plant have been dried up and quite likely blown away, and seemingly until the juices of the stalks have been completely sucked up. It is hard to resist the conviction that this can not be a mere coincidence; that, in short, these figures point to a real principle in the growth of the crop which the farmer can not afford to ignore. * * *

Considering then all the facts—the great labor of husking corn from the shock as compared with "picking" it from the standing stalks; the great difficulty in tying, hauling, and stacking or otherwise securing the fodder crop; and the great waste of fodder in the field and ultimate loss in feeding (which we have demonstrated time and again to amount to 20 to 60 per cent of the stalks)—it is perfectly clear to me that we must raise corn for corn, with no thought of fodder, and corn again which has no higher purpose than the production of fodder. We must, in short, have two corn fields on every farm, receiving radically different treatment, to correspond with the different purposes for which they are cultivated.

The weak point in the practice of Kansas farmers is the all but universal neglect of corn as a hay plant. It is far from my purpose to write in disparagement of the efforts so many of our best farmers are putting forth to secure grasses and clovers suited to our Kansas climate, but certainly the men who deplore the lack of tame grasses in Kansas forget that, so far as hay is concerned, they have in Indian corn and sorghum hay plants, which in our Kansas climate are superior for most of the purposes for which hay is used, to any of the so-called tame grasses, in certainty of yield, quality, and quantity of crop, and ease in handling if properly handled. * * *

By planting corn thickly a large yield of the best fodder, together with a large crop of poor corn may be had, and that very cheaply as I have shown in the experiments of previous years (see Report of the Professor of Agriculture, Kansas State Agricultural College, for 1883, p. 24).

As to the best means of securing this fodder when grown, the silo, doubtless, is the cheapest and most satisfactory method of preserving the crop; but where the use of the silo may not be had corn cut when the grain is in the dough state will cure perfectly and may be preserved (fodder and grain) in the shock in almost perfect condition until required for feeding in the winter.

Experiments with wheat (pp. 54–63).

For several years experiments with wheat have been in progress at the college farm, having for their objects (1) to show the comparative values of common and unusual sorts, and (2) to give expression to varying methods of treatment.

The results of our experience with something over one hundred sorts of winter wheat have abundantly satisfied me that the Kansas farmer can rely only upon the fine, early-ripening red sorts—often of Southern origin—of which Early May and Zimmerman are types. These are usually reckoned light-yielding sorts, but in Kansas soils, during favorable seasons, they often yield enormously. The coarse-growing, late-maturing sorts, like Clawson, Lancaster, and Egyptian sometimes do remarkably well, but much oftener they fail miserably.

A list of 51 varieties of winter wheat sown October 1, 1887, is given.

Of these, Hungarian, Red Russian, Red Line, Genoese (wholly killed), Sibley's New Golden, The Good, and Surprise suffered most from winter-killing, the loss amounting to fully one-half of all the plants in most cases. The varieties that sustained the least injuries were Theiss, Big English, Tuscan Island, Diehl-Mediterranean, Gypsy, Fultz, and Finley.

The appearance of chinch-bugs in great numbers in the spring made it necessary to plow the wheat under. The bugs were not destroyed, however, and did much damage to other crops.

To test the effects of growing wheat continuously without fertilizer or renovating treatment of any kind, an acre of land has been kept in wheat since 1880. During this period there have been two light and four large yields, and two complete failures (winter-killed). The average yield for 7 years has been nearly 23½ bushels.

Pasturing wheat.—The results of an experiment to observe the effect of pasturing winter wheat both in fall and spring are summarized in the following table:

Items.	Yield per acre.		Straw to bush. of grain.
	Grain.	Straw.	
	Bushels.	*Pounds.*	*Pounds.*
One acre grazed in fall	25.70	3,766	146
One-half acre grazed in spring—yield, 13.1 bushels grain, 1,662 pounds straw	26.20	3,324	127
One-fourth acre not grazed—yield, 6.4 bushels grain, 825 pounds straw.	25.60	3,300	128

The author is cautious in drawing conclusions from this experiment and recommends that the pasturing of wheat be tried only on wheat sown early enough in the fall to enable it to make a luxuriant growth.

Fertilizers and methods of cultivation.—Experiments with different fertilizers and methods of cultivation were tried on a strong clay soil of moderate fertility on twenty-one plats, each one twenty-fifth of an acre. The variety used was Zimmerman.

Plats 2 and 4 received an application of salt at the rate of 300 pounds per acre; plats 6 and 8 were top-dressed with rich, partly rotted dung, at the rate of 30 tons per acre; and land plaster was sown on plats 10 and 12 upon the basis of 200 pounds to the acre.

Plats 14 and 16 were thoroughly harrowed twice with the smoothing harrow.

From the "hoed" plats—18 and 20—each alternate row of wheat was removed preliminary to the hoeing, leaving the interspaces of the rows 10 inches wide; these were thoroughly hoed three times, at intervals of 10 days, beginning April 5.

The yield for each plat is given in a table which is condensed in the following summary:

Summary of yield of wheat per acre.

	Yield of plat.		Yield per acre.		Straw to bushel of grain.
	Cleaned grain.	Straw.	Cleaned grain.	Straw.	
	Pounds.	*Pounds.*	*Bushels.*	*Pounds.*	*Pounds.*
Plats 2 and 4—salt applied, 300 pounds per acre	94	194	39.00	4,857	124
Plats 1, 3, and 5 (adjacent 2 and 4)—nothing	83	162	34.00	4,058	119
Differences—gains and losses*	11	32	4.58	799	....
Plats 6 and 8—manure, 30 tons per acre	89	165	37.00	4,137	111
Plats 5, 7, and 9 (adjacent 6 and 8)—nothing	84	165	35.00	4,125	117
Differences—gains and losses	5	....	2.08	12	....
Plats 10 and 12—plaster, 200 pounds per acre	89	182	37.00	4,550	123
Plats 9, 11, and 13 (adjacent 10 and 12)—nothing	88	179	36.00	4,475	124
Differences—gains and losses	1	3	.41	75	....
Plats 14 and 16—barrowed	79	156	33.00	3,912½	118
Plats 13, 15, and 17 (adjacent 14 and 16)—nothing	89	174	37.00	4,350	117
Differences—gains and losses	−10	−18	−4.16	−438	....
Plats 18 and 20—hoed	76	120	31.00	3,012	97
Plats 17, 19, and 21 (adjacent 18 and 20)—nothing	88	165	36.00	4,125	114
Differences—gains and losses	−12	−45	−5.00	−1,123	....

*The minus sign (−) preceding a number indicates a loss for the particular method.

The general average of these experimental plats proves that the soil was rich and productive, furnishing every element needed for the development of the wheat plants.

* * *

The manured plats gave so slight an increase, as compared with the adjacent zero plats, that we are forced to conclude that the application in every case was not a benefit to the crop. The soil, or rather the crop, needed neither the gypsum nor the manure. * * *

The application of the salt was an undoubted benefit to the crop, as the tables plainly show. The effect of the salt was also strikingly shown in the peculiar bright color of the straw of the salted plats. * * *

The injury evidently done by the harrowing was perhaps chiefly due to the fact that the weighted harrow was dragged across the wheat rows, it being impossible from the arrangement of the plats to work the harrow in line with the rows of wheat.

Forage crops (pp. 63–69).—Notes on the following forage crops grown at the Station: cow-peas (*Dolichos sinensis* (?)), Rural Branching sorghum (*Sorghum vulgare*), Kaffir corn (*Sorghum vulgare*), yellow millo maize (*Sorghum vulgare*), pearl millet (*Pennisetum spicatum*), African millet (*Sorghum vulgare*), Japan maize (*Zea mays*), teosinte (*Euchlæna luxurians*), and 7 varieties of ensilage corn.

From the knowledge we now have, it seems that cow-peas can not be profitably raised for forage, owing to the small yield of peas and poor character of the forage it yields.

The non-saccharine sorghums are worth a careful trial. They resist drought well and will give a sure crop of both grain and forage in a season when corn will entirely fail. They will also give fair crops on very poor land. Rural Branching sorghum has been the most satisfactory variety grown this season, African millet standing second. African millet has been tried for a number of years on the college farm, and has always been a favorite variety.

Kaffir corn has been tried here for 2 years. It grows quite surely and yields more seed per acre than the other varieties of sorghum. The forage has not proved valuable with us for feeding, and it is doubtful if this variety is equal in value to either Rural Branching sorghum or African millet.

Teosinte, if tried at all, should be planted very sparingly until the farmer has settled for himself its value. The high price of the seed ($2.75 per pound), the protection which it affords for chinch-bugs, and the immature condition in which the crop must be harvested, render teosinte of doubtful value.

In feeding ensilage the leaf is of greater value than the stalk, and that variety which produces the greatest weight of leaves per acre, other things being equal, is the best variety to plant for ensilage. Of the sorts tested this year the choice lies between the White Flat ensilage and the Southern Horse Tooth ensilage.

The milk and butter product as influenced by the grain ration when fed with ample pasturage (pp. 69–95).

In general practice we rest content when our herds and flocks are provided with abundant nutritious pasturage. Few will deny that productive perennial pastures furnish the cheapest food for cattle, whether kept for milk or beef. Nevertheless, in the case of cattle under process of fattening, the practice of supplementing pasturage with more or less of grain food finds favor with a constantly increasing number of careful managers. They recognize the fact that the profit in farming, as in other lines of activity, comes from doing a little more and better than we really seem compelled by circumstances to do. With this thought in mind, it seemed worth while to inquire into the advantages, if any, of adding to the common summer pasturage of milch cows a liberal feed of grain.

Experiment with pasture alone vs. pasture supplemented by bran or corn meal or oats.—The general plan of the experiment was as stated below.

Cows.—At first six cows were used, four three-year-old Jerseys, Eva, Prudie, Pansy, and Pixley III, and two six-year-old grades, White and Ruby. They were divided into three sets of two each. In the course of the experiment Pixley III proved to be in poor condition and was withdrawn.

The Jerseys were good average specimens of the breed, perhaps something better than the ordinary, but certainly they were not remarkable as milk or butter producers. The grades were strongly tinctured with Shorthorn blood, and both animals were reckoned "good milkers."

Feeding.

The cows were fed in sets of two each, each pair receiving a particular kind of feed for a space of 7 days, when feed of another kind was used for 7 days, and so on in the case of each pair to to the end of the experiment. Thus the cows Eva and Prudie began the experiment with pasture alone; the simple pasture was succeeded by bran, and bran by oats, which in turn was followed by pasture alone. The subjoined tabular history of the experiment shows the order of the changes of feed in the case of each set. The grain referred to was fed in quantities to suit the appetite of each cow, and always was given in addition to ample pasturage, consisting for the most part of orchard grass and red clover. On the first day of each period (Saturday) no record was made either of the food consumed or milk yielded, and during the last two periods only the records of the last 3 days of each were taken.

Time.—The experiment continued from July 15 to September 17, 1888.

The experiment really began July 11, but on account of unavoidable mistakes and accidents made in learning the best methods of work, the results of the first four days' work are omitted.

Weight of cows.

The weight of each of the sets of cows was taken weekly, beginning August 12. The change in the condition of the cows from week to week was very slight, if anything. Thus the united weights of Eva and Prudie August 12 were 1,435 pounds, and at the conclusion of the experiment, 1,465. In the same time Pansy gained the difference between 835 and 890 pounds, while the two grades changed in weight from 2,310 to 2,355. These figures show that the cows certainly lost no flesh, and the difference in the contents of the stomachs of the cows at the first and last weighings seems a quite sufficient explanation of the apparent gain.

Milking, setting of milk.

The milking was done at intervals of almost 12 hours, the same men doing the work throughout with scarcely an interruption. As soon as possible after milking, the milk was weighed and thoroughly mixed, and samples from each cow selected for testing. For the cream test a graduated glass jar was filled as required; for the butter test 2 pounds of milk were at first used, and afterwards 1 kilogram (2.2 pounds avoirdupois, nearly). The milk under examination for butter was placed in glass fruit jars, and these with the graduated jars were promptly set in a large tank holding water at 60°, deep enough to submerge the milk. After considerable experience it became clearly apparent that more butter of better quality was obtained when the milk was set about 48 hours. If the setting was prolonged much past 60 hours an inevitable loss followed, as was also the case when the churning was performed before the milk had stood 48 hours. It will be borne in mind that in dealing with the small quantities of milk, which alone could be used in the experiment, the setting of the milk had reference to ripening as well as raising the cream.

Churning butter.

The rule, with very few exceptions, was to churn morning and evening's milk at the same time, the former having stood 48 hours and the latter 60. At first (to July 20) the whole milk was churned, but the difficulty encountered in separating accurately and completely the small amount of butter contained in the proportionately large mass of milk made it necessary to return to the practice of skimming the samples and churning the cream with a portion of water added sufficient to reduce the cream to the required temperature.

The churning was done with a Cherry test churn, a device quite extensively used in creameries for testing the milk of patrons. It consists of a strong frame having seats for a dozen 2-quart cans, each held in place by the steady pressure of a spiral spring. The frame and its load of cans is given an oscillating movement by a crank and pitman, and the motion thus obtained is controlled by a balance-wheel. Accompanying the machine was a set of metallic 2-quart cans for use in churning. These we attempted to use for the purpose for which they were designed, but by reason of inferior workmanship they proved worthless, leaking so badly that we were forced to substitute for them 2-quart glass fruit jars, which we found to answer our purpose well. The glass jars had the additional advantage over the metallic cans in that the condition of the cream at any stage of the churning process could be seen at a glance without uncorking the jars.

The process of gathering and working the butter was necessarily a simple one. The buttermilk contained in each jar as soon as churned was separated from the butter by straining through a 6-inch square piece of cheese cloth previously dampened, and accurately weighed. The retained butter was then washed in cold water and thoroughly kneaded with the hand, until the moisture was very thoroughly eliminated. The object was to bring the butter to as nearly as possible the condition of a good marketable product.

Analysis of milk, proportions of fat.

On August 3 and thereafter daily throughout the experiment, the churning was supplemented by analysis made after Short's method of determining fat in milk (a method devised by Mr. F. C. Short, assistant chemist of the Wisconsin Experiment Station).* In the case of nearly every sample thus treated the analysis was made in duplicate, and for the object of correcting any errors that otherwise might be passed unobserved. During the fifty-odd days of the experiment no fewer than 237 different samples of milk were churned and 153 samples were analyzed, mostly in duplicate.

The daily record of the experiment is given in a detailed table, showing for each cow the total yield of milk, percentage of cream, temperature of churning, time in minutes required for churning, per cent of butter (pounds of butter from 100 pounds of milk), and per cent of fats in milk, as found by Short's method of analysis. The results are summarized in another table as follows:

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* Fifth Annual Report of Wisconsin Experiment Station, p. 124.

Results of experiments, average daily feeds of grain, yield of milk, and percentages of cream, of butter as obtained from milk by churning, and of fat as found in milk by analysis.

Daily feed.	Milk.		Cream.		Butter.		Fat (Short's method).	
	Daily yield per cow.	Gain (+) or loss (—), compared with pasture alone.	Average yield (bulk).	Gain (+) or loss (—), compared with pasture alone.	Average yield.	Gain (+) or loss (—), compared with pasture alone.	Average yield.	Gain (+) or loss (—), compared with pasture alone.
Eva and Prudie, Jerseys:	*Pounds.*	*Per cent.*	*Per ct.*	*Per cent.*	*Per ct.*	*Per cent.*	*Per ct.*	*Per cent.*
Pasture alone	17.30	....	11.02	....	4.81	....	5.06	....
Pasture and corn meal, 10.66 pounds	20.41	+17.97	10.75	—2.45	4.86	+1.03	4.99	—1.38
Pasture and bran, 9.83 pounds	17.12	—1.05	10.45	—5.17	4.25	—11.64	5.16	+1.97
Pasture and oats, ground, 8 pounds	20.50	+18.49	10.66	—3.26	5.56	+15.59	5.47	+8.10
Pansy, Jersey:								
Pasture alone	16.08	....	10.13	....	4.38	....	5.03	....
Pasture and corn meal, 16 pounds	20.83	+29.54	10.00	—1.28	4.63	+5.71	4.48	—10.93
Pasture and bran, 14.33 pounds	21.16	+31.59	10.25	+1.18	4.81	+9.81	4.65	—7.55
Pasture and oats, ground, 11.83 pounds.	22.04	+37.06	9.50	—6.22	5.02	+14.61	4.81	—4.37
White and Ruby:								
Pasture alone	16.00	....	11.45	....	3.61	....	4.69	....
Pasture and corn meal, 11.66 pounds	22.36	+39.75	10.19	—11.05	3.63	+.55	4.49	—4.26
Pasture and bran, 11 pounds	21.00	+31.25	11.16	—2.53	3.40	—5.81	3.88	—17.27
Pasture and oats, ground, 18.8 pounds..	21.41	+33.81	10.75	—6.11	4.23	+17.17	4.33	—7.67
Totals and averages for all the cows:								
Pasture alone	16.62	....	10.80	....	4.35	....	4.95	....
Pasture and corn meal, 11.93 pounds	21.90	+31.76	10.20	—5.55	4.17	—4.13	4.61	—6.86
Pasture and bran, 10.85 pounds	19.29	+16.07	10.66	—1.29	4.01	—7.81	4.48	—9.49
Pasture and oats, ground, 12.64 pounds	21.30	+28.22	10.00	—6.48	4.96	+14.02	4.73	—4.44

The lesson plainly taught by the above table is that the grain, in the case of corn meal, bran, and oats, was fed at a considerable loss. The grain feed added materially to the milk yield, corn meal showing the largest increase, the gain in this case amounting to more than 31 per cent. But that this gain did not nearly pay expenses is shown in the table. We here see that while the flow of milk was considerably increased, the gain—amounting to more than 31 per cent of the yield obtained from pasture alone—was quite incommensurate with the cost of the supplementary grain ration. This is further shown by the fact that the cream per cent was considerably diminished. The per cent of butter churned out was also decreased, except in the case of ground oats fed, when a considerable increase in the per cent of churned butter was noticed, accompanied by a gain in the amount of fat obtained by analysis, although even then the per cent of fat yielded was 4.41 less than that given when pasture alone was the feed of the cows.

These figures, representing as they do per cents of the milk yielded, are, however, misleading when considered by themselves. It is not to be supposed that the cows gave less butter when fed on grain and pasture than was obtained when pasture alone was the feed; they really gave much more. The diminished per cents simply show that the milk increased rapidly as a result of the extra feeding, while the increase in the amount of butter and other products of milk was made much less rapidly. This fact will be clearly seen in the following table, which shows the actual daily products of the milk in pounds of cream, butter, and fat:

Summary of average daily yields of milk, cream, butter, and milk fats in pounds, and gains for grain fed.

	Milk.		Cream.		Butter.		Fat.	
	Daily yield per cow.	Gain for grain fed.	Daily yield per cow.	Gain for grain fed.	Daily yield per cow.	Gain for grain fed.	Daily yield per cow.	Gain for grain fed.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Pasture alone	16.62	....	1.79	....	0.72	....	0.82	....
Pasture and corn meal, 11.93 pounds	21.90	5.28	2.23	0.44	0.91	0.19	1.01	0.19
Pasture and bran, 10.85 pounds	19.29	2.67	2.05	0.26	0.77	0.05	0.86	0.04
Pasture and ground oats, 12.64 pounds	21.31	4.69	2.15	0.36	1.05	0.33	1.00	0.18

Amounts of cream, yield of butter, and percentages of fat in milk.

The amount of cream thrown up by the milk, and its relation to the yield of butter and fat are somewhat strangely shown in this experiment. Popularly the notion is held that the cream yielded by milk is a safe index of its butter capacity. It is, of course, true that rich milk throws up heavy and abundant cream, while thin and watery milk gives a light skimming of cream; but what is plainly not true, according to the facts of this experiment, is the assumption that the milk is valuable in proportion to the cream it yields, implying that cream is everywhere alike in value. In the common practice of buying cream by the "gauge," it is supposed that the product of cream in butter is uniform. In this experiment of ours cream was the one discordant element. In the case of every cow employed, and with each kind of feed, the milk giving the largest display of cream often gave the least butter product, and the reverse. As far as we could judge, the character of the cream varies quite as much as the milk does in its original condition. In proof of this we submit the following tabular statement, in which the average yield of butter and fat of all the different cream per cents obtained in the entire experiment is given in horizontal columns.

Butter yield and percentages of fat with different percentages (8 *to* 14 *per cent*) *of cream.*

	Cream per cents.						
	8.	9.	10.	11.	12.	13.	14.
Butter, per cent	4.45	4.86	4.42	4.03	4.20	4.21	5.11
Fat, per cent	4.24	4.28	4.83	4.74	5.06	4.75	5.29
Theoretical fat, proportion to cream	......	4.77	5.30	5.83	6.36	6.89	7.42

It seems scarcely necessary to add anything in the way of comment to the plain facts of the table. We see here that milk showing 8 per cent of cream gives a larger yield of butter than is obtained from milk giving 10, 11, 12, or even 13 per cent of cream; and while the column of fat per cents shows a slight increase as the amount of cream increases, this gain comes far short of what it should be to keep pace with the increased amount of cream. This is seen at a glance in the column of "theoretical fat," where is given the calculated amount of fat for each per cent of cream, taking as the basis of comparison the fat yielded by the least per cent of cream (8). These facts are, if possible, brought out more strikingly in particular cases exhibited in the table giving the daily record of the experiment, where the neutralizing effect of the group averages is not seen.

The cream gauge in the creamery.

The truth is that the man who buys the milk of a large number of herds, good, bad, and indifferent, paying for it by the gauges of cream which it yields, is probably not greatly the loser or gainer thereby. Experience has taught him the amount of butter he has reason to expect from the composite cream; but the loss to patrons, especially those whose herds have been bred up in dairy lines, must often be very great in the averaging process. The farmer whose Jerseys, as in the case of our Pansy, gave 9½ to 10 per cent of cream, yielding nearly 5 per cent of butter, must, if all patrons are paid alike, contribute in the course of a year a very pretty sum towards the support of his neighbor's herd of scrubs, which, like our White and Ruby, gave nearly 11 per cent of cream and only 3¾ per cent of butter.

Short's method of milk analysis.—This was found to be reasonably accurate, "nevertheless we are confident that the new method will not, in the esteem of practical men, supplant the old test and churning of samples now so generally in vogue." The objections urged against the new method are the length of time required for the analysis and the fact that it "takes no account of the churnability of the milk."

Churning quality of milk.

It is interesting to observe the influence of the different foods upon the churning quality of milk. The pasture alone, the bran and corn meal, seem to have had about an equal influence upon the churnability of milk, or rather the grain had no influence at all. On the other hand the ration of ground oats, with every cow, during every feeding period in which oats were used, added markedly to the accessibility of the fat of the milk. It mattered not whether the oats were consumed liberally, as by White and Ruby, or sparingly, as in the case of Eva and Prudie, without increasing the flow of milk or the total fat, this grain always and without delay added largely to the butter product.

The pressure of contained ensilage upon the walls of the silo (pp. 95–99).

In planning the construction of a silo for the Kansas Experiment Station during the present summer (1888) the question of the proper strength of walls arose in the very outset. The two essential facts in the structure of the silo are: (1) The walls must be so constructed as to exclude both air and cold; and (2) they must be sufficiently strong to resist the pressure of the inclosed ensilage. * * * In the construction of the Station silo, 2 by 8 inch hard-pine joists, set 16 inches apart, were used, and these so far have been deflected but slightly by the contained ensilage. It should be said that the silo here referred to, and employed in the experiment herein detailed, is 13 by 18 feet floor area, and 21 feet in height. Midway up it passes through the barn floor, which supports it rigidly at this point.

In view of the difficulty of applying mathematical formulas because of the very variable condition of ensilage both in and out of the silo, the apparatus described and illustrated in the report was devised by the writer with the object of establishing empirically facts relating to the side pressure of ensilage. The observations were made while the silo was being filled with corn and for some days after. A "diaphragm" was used for the purpose, consisting of a hinged-door-like arrangement close to the side wall at the bottom of the silo. The pressure of the ensilage upon this was measured by a dynamometer.

The tabular record includes the day and hour of observation, depth of ensilage, reading of dynamometer, estimated total pressure upon "diaphragm," and estimated pressure per square foot. The greatest pressure (57 pounds per square foot) was when the ensilage was 19 feet deep. After this the pressure diminished gradually for more than 2 weeks.

These facts show that the pressure upon the silo walls by contained ensilage is very great. A silo usually has a long life, and during its existence supports a great variety of vegetable substance. Like the wagon the walls of the silo must be equal to the task of supporting the heaviest burden that will be put upon them.

Relation of rain fall to the corn crop (pp. 99–116).—This includes a tabular record of the rain-fall from May to September inclusive, for each year from 1874 to 1888 inclusive, with brief notes on the weather and crops for each season of growth. The data are summarized as follows:

Summary of rain-fall and corn crop.

Year.	Rain-fall of March and April.	Rain-fall of growing months.				Total rain-fall for growing months.	Yield of corn per acre.
		May.	June.	July.	August.		
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Bush.*
1874	1. 40	2. 98	4. 31	. 18	. 25	7. 72	....
1875	2. 71	2. 46	2. 06	3. 23	1. 40	9. 15	27½
1876	11. 48	5. 73	4. 60	5. 65	10. 70	26. 68	56⅝
1877	2. 70	5. 20	6. 76	4. 16	2. 78	18. 90	48
1878	3. 79	4. 04	5. 02	12. 71	2. 66	24. 43	45
1879	3. 21	1. 79	8. 48	4. 91	1. 61	16. 79	47
1880	1. 58	3. 74	3. 92	3. 78	8. 51	19. 95	55
1881	2. 31	6. 67	3. 38	1. 32	. 43	11. 80	13
1882	4. 27	5. 43	3. 08	7. 73	. 87	17. 11	50
1883	3. 41	4. 83	9. 58	4. 15	3. 94	22. 50	40
1884	5. 59	4. 63	3. 82	5. 54	6. 21	20. 20	55
1885	4. 03	4. 30	1. 67	4. 99	. 89	11. 85	47½
1886	6. 31	4. 87	5. 38	2. 84	2. 06	15. 15	30
1887	3. 27	2. 54	4. 57	. 90	6. 66	14. 67	....
1888	3. 85	2. 25	5. 22	4. 02	4. 46	12. 15	40
Averages	3. 99	4. 09	4. 78	4. 40	3. 56	16. 60	....

The fact of this summary that strikes one most forcibly is the tremendous volume of water that falls upon Kansas fields during the ordinary season of growth. We here see that in "droughty Kansas" the average rain-fall of four months is more than 16½ inches—but little less than the total precipitation of rainy England for the entire year.*

If the facts above do not tell us in precise terms the rain-fall required to produce our standard Kansas farm crop during a season in all other respects an average one, they indicate certain facts bearing thereon of general interest and importance.

(1) We see that the months of July and August are the weak ones as to rain-fall, showing the widest fluctuations from the average, as well as the lowest average of the growing months.

(2) In July the crop shows the greatest sensitiveness to the influence of the rain supply, a dry July being always accompanied by a short corn crop, except in rare cases where the influence of the July drought has been lessened by abundant rains late in June and early in August.

(3) With a full July average, as in 1885, or where the rain-fall of June and August is abundant, as in 1888, 12 inches of rain for the growing months will "make" the crop, although it is certain often to be brought perilously near a season of drought.

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* Prothero in "The Pioneers and Progress of English Farming" says (p. 40): "The climate worsened after 1764; the mean average rain-fall from 1741 to 1750 was 18½ inches; from 1771 to 1780 it averaged 26 inches."

REPORT OF CHEMICAL DEPARTMENT, G. H. FAILYER, M. S., AND J. T. WILLARD, M. S. (pp. 117–164).

The work reported upon is that which has been completed to date. It comprises (1) an inquiry into the shrinkage of hay when stacked in the mow; (2) a comparison of varieties of sorghum; (3) a test of the keeping qualities of sorghum; (4) an examination of individual stalks of sorghum with a view to improving the plant; (5) a trial of fertilizers on sorghum; (6) the working out of a new method of analyzing milk, with a comparison of results by the churn.

Work under way, but upon which no report is made because of incompleteness, includes analyses of grains, grasses, and fodders; an investigation into the sources of the nitrogen of plants; and a determination of the nitrogen compounds of rain-waters.

Shrinkage of hay in mow (pp. 117–121).

The plan of the experiment was to fill a bag of very thin muslin with the hay while it was being hauled from the field and to bury it in a mow of hay and leave it until the whole was certainly air-dry, when the bag of hay was to be weighed and its per cent of loss or gain determined. Determination was made of the total amount of water in the hay at the time it was hauled in and the sample taken, and also of that yet contained in it at the conclusion of the experiment. The thirteen samples were buried at the dates given in the accompanying table, and eleven of them were taken out on the 15th day of December. It will be seen that the samples first buried were kept in the mow for a period of almost exactly 6 months, while the shortest time any was kept was 4 months. Of course all had much more than ample time to dry out as much as they would.

Summary of experiment.

No. of sample.	Kind of hay.	When cut.	When put in mow.	When taken from mow.	Weight when put in mow.	Weight when taken from mow.	Loss (−), or gain (+).	Water in hay when put in mow.	Water in hay when taken from mow.	Water in hay when put in mow, calculated from columns 8 and 10.
1	2	3	4	5	6	7	8	9	10	11
					Pounds.	*Pounds.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1	Mixture of orchard grass, clover, and a little blue-grass	June 4	June 12*	Dec. 15	7.44	6.90	− 5.71	14.32	10.54	15.65
2	Blue-grass	June 4	June 12	Dec. 15	9.06	8.16	−10.05	18.21	10.60	19.59
3	Orchard grass and clover..	June 8	June 12	Dec. 15	6.69	6.08	− 9.01	16.50	11.80	19.75
4	Millet	....	July 21	Mar. 11†	6.63	5.68	−14.25	24.42	8.89	21.86
5	....do	....	July 27	....	....	......	......	23.10	....	....
6	Clover........	July 30	July 31	Dec. 15	5.06	5.22	+ 3.17	9.82	11.87	9.08
7	Prairie hay ...	....	Aug. 11	Dec. 15	5.06	4.87	− 3.55	15.30	10.64	13.81
8	....do	Aug. 11	Aug. 11	Dec. 15	6.06	5.85	− 3.52	12.85	10.73	13.87
9	....do	Aug. 15	Aug. 16	Dec. 15	6.62	6.40	− 3.42	10.88	10.04	13.11
10	....do	Aug. 13	Aug. 16	Dec. 15	4.87	4.86	− .29	10.81	10.77	11.03
11	....do	Aug. 14	Aug. 16	Dec. 15	6.06	6.03	− .58	10.83	10.75	11.26
12	....do	Aug. 14	Aug. 16	Dec. 15	4.56	4.58	+ .40	10.02	10.72	10.36
13	....do‡	Aug. 9	Aug. 16	Dec. 15	6.00	5.56	− 7.33	17.13	10.63	15.51

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[*] The hay was put in on the 5th, but sample not taken until 12th.

[†] Owing to the accident by which this report is delayed in coming out, opportunity is given to present further facts upon one of the samples of millet hay. It will be observed that the loss of water by the millet while in the mow is large, amounting to one-sixth. Owing to the slowness with which the stems of millet dry out, this hay seems to be very liable to be hauled in before it is well cured.

[‡] Very coarse.

The conclusion drawn is that if the hay is not green and is well cured when stored no great shrinkage need be feared.

A comparison of varieties of sorghum (pp. 122–138).

For our first season's work it was planned to collect data upon the varieties at command and to prepare for future efforts at improving sorghum as a sugar plant. The first of these objects included as its most important feature the determination of the sucrose and glucose. But, as a very important part of the work, full data upon the physical characters of the canes were obtained. The nature of this will be seen by reference to the table.

The data given include dates of analyses, number of stalks, average height and weight, average number of joints and dead leaves, per cent of tops, leaves, clean cane, and juice calculated on clean cane, specific gravity of juice, per cent of cane, reducing and total sugar in juice. There are also descriptive notes on some of the varieties.

The keeping qualities of sorghum (pp. 139–141).

It has long been known that the uncrystallizable sugar decreases and the crystallizable sugar increases as the cane develops. Our work did not begin on the sorghum until it had reached a workable condition. The figures in the table show that the juices of those varieties which became fully ripe before frost continued to improve until the cane was dead ripe, and then continued sensibly constant until the cane was injured by freezing; then rapid deterioration set in. The diagram shows to the eye these facts. It is made up from the table. Enough of the varieties have been included in the diagram to show that this kind of development is a general rule. The principal point to which attention is called is the fact that these varieties at least retain their good qualities after ripening as long as the canes are left standing in the field without being injured by some external agent.

Attempts to improve sorghum by seed selection (pp. 141–147).

The great success attending the efforts to improve the quality of beets for sugar making, led to hopes that an analogous change might be effected in the sorghum plant. * * * In 1885 and 1886 some work was done in our laboratory in an attempt to improve the quality of sorghum by seed selection. The work was temporarily discontinued, but was taken up again the past season. * * * To determine to what extent individual stalks vary when grown under the same circumstances, as well as to form a basis for present selection of seed and for future comparison, analyses were made of the juice pressed separately from a number of stalks. The varieties from which individual stalk selections were made were those which the general comparison of varieties showed to be promising sorts. This judgment was based upon the sugar content.

A table and diagram show the extreme variations of the sugar content in single stalks from 7 varieties.

Fertilizers on sorghum (pp. 147, 148).—The fertilizers used were superphosphate, nitrate of soda, lime, and plaster. From the tabular record given it appears that there was very little effect produced by the fertilizer.

A new method of milk analysis for the use of dairymen, and a comparison of its results with those obtained by the churn (pp. 149–164).—"A modification of a process described by Dr. W. Schmid in the *Zeitschrift für Analytische Chemie*, Vol. XXVII, 1888, p. 464," was devised by the author and is described and illustrated in the report. The results of the analyses made by this method were compared with tests made with the churn to determine the quality of the milk by the yield of butter.

Tables give the results for the six samples of milk. They show the per cent of fat in the milk; the per cent of butter obtained, weighed both moist and dry; the composition of the dry butter; and the per cent of fat extracted as butter from the milk.

An examination of the tables will show that the yield of butter varied with circumstances with the greatest irregularity. Even with duplicates that are treated exactly alike, the difference is sometimes about 20 per cent of the least quantity. * * * If we inquire why the amount of butter should so vary the answer in general terms will be that not all the fat is ever extracted from milk by the churn; that what we get and weigh as butter is made up of true butter fat, curd, and water. These are in not at all constant proportions. This fact is well brought out in the part of the table showing the composition of the butter. * * * It is possible that the yield of butter may be made to serve as a test of the quality of milk, but it is evident that the treatment given both milk and butter is by no means an indifferent matter.

REPORT OF THE DEPARTMENT OF HORTICULTURE AND ENTOMOLOGY, E. A. POPENOE, M. A., C. L. MARLATT, M. S., AND S. C. MASON (pp. 165–280)

Here are given the results of experiments in spraying the apple orchard to prevent the ravages of the larva of the codling moth; of observations on the life history and habits of certain injurious insects, with the means of their suppression; and of garden trials of vegetables, including potatoes, peas, and tomatoes.

Experiments in spraying apple-trees to protect the fruit from the apple worm (pp. 165–193).—The codling moth is the most formidable insect foe to Kansas orchards.

For this reason, and because it seemed to us that more extended definite trial is needed to settle the value of popular modes of warfare against the insect, it was decided to place under experiment one of the apple orchards upon the college grounds, an orchard numbering 268 trees, including 47 different varieties, the chief points which it was desired to include in the observation being: (1) the comparative value of certain different compounds of arsenic as preventive of the ravages of the larva of the codling moth; (2) the result of a repetition of application in comparison with a single application of the same mixture; (3) the relative injury to the foliage of the apple under the different treatments; and (4) the utility of banding the trees for the capture of the full-grown larvæ.

The insecticides used were London purple (1 ounce to 4 and 8 gallons of water), Paris green (1 ounce to 20, 10, 5, and 3½ gallons of water), and "Climax Insect Poison" (1½ pounds to 50 gallons of water). In some cases one and in others two applications were made.

The first result of the spraying was the scalding of the foliage of the trees sprayed. With some varieties the amount of foliage destroyed in this way was considerable, while other varieties suffered little or not at all. The amount of scalded foliage was found to vary also under different treatments, and in a few cases, for which no explanation was found, an important variation under apparently similar conditions was noted.

No very definite conclusions were reached regarding the relative value of the different mixtures used in these experiments.

An average of the percentages shows a gain of 3.2 per cent under a repetition of the treatment even after the interval (perhaps too great under the circumstances) of 9 or 10 days. * * * In several cases it became necessary to gather a part of the fruit upon certain trees some time before the date when the fruit of that sort was in general ready for market or storage. In these few cases it appears that the percentage of infested fruit is very much smaller up to the middle of August, while for the same tree the percentage is later materially increased. * * *

That this difference in favor of the early-picked fruit is not entirely due to the fact, as some claim, that the apples attacked by the first brood of larvæ mostly fall from the tree while those later attacked largely hang until gathered, is shown by the percentages of infested fruit in the sum of the fallen and gathered fruit in each case up to the earlier date given. * * *

The above showing makes prominent one weak point in this practice of spraying. While it is a most important and valuable method in the protection of early-maturing fruit, its value for late fruit is lessened by the appearance of a second brood of the larvæ, which have now the freedom of the orchard; and it is after all to these that we are indebted for the greater part of the damage to our winter fruit. The argument follows that even with the most careful and thorough work with the spraying engine, the long-recommended practices of daily gathering and destroying the fallen fruit, and of trapping and destroying the larvæ and moths by all possible means, must still be made use of; and these not only by the interested orchardist himself, but also by his neighbors, else is his own work but partly repaid.

It is a question of importance why some varieties of apples regularly show in our tables so much greater percentage of infested fruit than do others under the same treatment and surroundings. It may be suggested that application of the poison to all at the same absolute time instead of at the same relative time or age of the fruit, will largely account for this. Again, the character, conformation, and surface of the apple itself may be in close relation to this difference: but upon this point further observation will be made before conclusions are offered. * * *

Following the spraying the trees were banded for the purpose of trapping the larvæ after they had left the apple. Bands of the ordinary felt paper sold for carpet lining were cut about 10 inches wide and long enough to go around the trunk of the tree below the branches, overlapping a few inches. Divided trunks received bands about each division, the united records of the several bands being counted as one. * * * As our records show there were gathered, by a very close approximation, over 238,000 infested apples from the total of over 642,000. From under the bands there were taken during the season, by actual count, 17,245 larvæ and 3,153 pupæ of the codling moth, or a total of 20,398 insects. Making no account of cases where the same larva had injured two apples or where one apple had contained two larvæ, it may be stated that the captures represented about 8.5 per cent of the insects that had done the injury. Viewing in its full bearing the fact of the destruction of this number of insects that had escaped the poison, and the slight expense of this part of the work, the question of the profit of banding the trees seems to be satisfactorily answered in the affirmative.

Full details of the experiment are given in tables covering about 20 pages.

Observations upon injurious insects (pp. 194–225), (illustrated).—Notes on the ash saw-fly (*Monophadnus bardus*, Say), sycamore forktail (*Heterocampa unicolor*, Pack.), sycamore leaf beetle (*Chlamys plicata*, Fab.), the apple-tree flea beetle (*Graptodera foliacea*, Lec.), apple twig borer (*Amphicerus bicaudatus*, Say), and box-elder bug (*Leptocoris trivittatus*, Say).

Garden trials of vegetables (pp. 226–280).—*Potatoes* (pp. 226–255).—A tabular record of the yield of 194 varieties, with brief notes on each, *Peas* (pp. 256–271).—A tabular record of the yield of 72 varieties (in 140 lots), with notes on each lot.

Tomatoes (pp. 271–280).—A tabular record for 53 varieties (in 83 lots), with notes on each lot.

REPORT OF THE BOTANICAL DEPARTMENT, W. A. KELLERMAN, PH. D., AND W. T. SWINGLE, B. S. (pp. 281–347).

Sorghum blight (pp. 281–302).—An account of observations made in 1888 on this disease as occurring at the college farm and on the bacterium (*Bacillus sorghi*) which is thought to be the cause of the disease. This bacterium was first observed by Professor T. J. Burrill, of the University of Illinois, in 1886.* In this article the varieties of sorghum and some other plants attacked by the disease are given, and the former are classified according to the amount of injury inflicted. The character of the disease is described and illustrated by three colored plates; brief statements regarding bacteria in general are made, and the characters of the *Bacillus sorghi* described. There are also a general account of the cultures made and notes on 11 inoculation experiments—9 on sorghum, 1 on wood grass (*Chrysopogon nutans*), and 1 on corn. Six of the sorghum plants showed stains of the disease. Soil tests in pots indicated that "the disease is transmissible, to some extent at least, through the agency of the soil." Rotation of crops, and especially the burning of all diseased plants, are recommended as means of preventing the spread of the disease.

Branch knot of the hackberry (pp. 302–315).—A disease of the hackberry tree (*Celtis occidentalis*, L.) "causing the formation of 'knots,' composed of usually more or less compact twigs on the branches," of both wild and transplanted trees has been observed near the Station and elsewhere in the State. In March, 1888, it was discovered that the buds on the knots were infested with a powdery mildew and a gall mite.

The mildew proved to be a new species, and was accordingly described in the Journal of Mycology, Vol. IV (1888), pp. 93 and 94, as follows:

"*Sphærotheca phytoptophila* (Kell. & Sw.).—Mycelium very sparse; perithecia globular, dark brown or black, obscurely reticulate, 60–80 micr., mostly 65–75 micr. in diameter; appendages few, more or less evanescent, dark brown, irregular, but usually about 6 micr. in diameter, and mostly longer than the diameter of the perithecia, often septate. Asci large, hyaline, broadly oval, containing 8 spores, which are hyaline, oval, regular in size, 15 by 24–28 micr. Conidial stage: Mycelium more abundant, conidiophores hyaline, erect, total height (including conidia) 150–220 micr. by 9–13 micr. in diameter, conidia oval hyaline, continuous, granular within, 15 by 21–29, mostly 15 by 27 micr. On *Celtis occidentalis*, Manhattan, Kansas.

"The fungus is found associated with *Phytoptus* (an undescribed species) on hackberry (*Celtis*). The distortions caused by the insect, or perhaps by both insect and fungus, consist of a multitude of abnormal, more or less abortive, branches, that form a compact knot ½ to 1½ inches in diameter; a few of the branchlets are prolonged a few inches, and themselves bear smaller knots of similar structure. The abortive branchlets have excessively numerous buds, all infested by the insect and covered by the fungus. The conidial stage is found associated with the perithecia, and sometimes even extending out on the twigs to the under side of the leaves. The perithecia are found in the spring, but do not mature their spores till late fall or winter."

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* See Proceedings of the Eighth Annual Meeting of the Society for the Promotion of Agricultural Science (1887) and The Microscope, November, 1887, Vol. VII, No. 11.

As far as observed, the fungus and the insect were always associated.

The infested trees bear knots composed of numerous abortive branchlets, which often bear secondary knots. * * * These knots are usually most abundant on the lower branches of the tree, but in some cases large knots were seen on the topmost branches. The injuries to the tree consist (1) of disfiguration, sometimes ruining it as an ornamental plant; (2) in waste of nourishment consumed in building knots useless to the tree, which otherwise would have contributed to the growth of branches and leaves; and (3) of decay of the branches attacked. This decay usually extends no further than the branches attacked, but sometimes it involves the trunk also.

Of the injuries mentioned the first is perhaps the most important, though the second and third may lower the vitality and cause the dwarfing or even death of the whole tree. The first appearance of the disease is almost invariably in the buds, on wood at least 1 year old. * * * Usually these infested buds produce the following year shoots which often make a vigorous growth and bear numerous buds or similar abortive branchlets. * * *

During the following year the development of the knot varies somewhat according to the vigor of the branch attacked. If the latter is healthy and making rapid growth its buds develop into branchlets similar to the original branch, and these secondary diseased twigs may also produce diseased twigs in the same manner. If this mode of growth is continued several years a loose or open cluster of diseased twigs is formed. * * * If, on the other hand, the attacked branch be weak the growth after the second year is different; the lateral buds fail to develop, and only those at the base grow, producing a multitude of abortive twigs, themselves clothed with perfect buds only near the base. When this mode of development continues several years a very compact knot is formed, having a firm, woody center often an inch or more in diameter. This knot is clothed with very numerous dwarfed twigs, liberally supplied with the infested swollen buds at the base.

These two types of knots are shown in two plates. * * * The knots usually continue to grow many years. Examples were abundantly found which must have been at least 6 or 8 years old. Finally the portion of the branch bearing the knot dies or the knot itself dies, leaving an excrescence on the branch.

A brief account of the characters of the *Erysipheæ* is given, and a detailed description of *Cicinnobolus cesatii* (De Bary) found on the conidial stage of the *Sphærotheca.* The gall mite (*Phytoptus* sp.) associated with the fungus is briefly described. "It appears that sulphur, applied in several ways and various combinations," has been the most effective of the remedies proposed. The diseased portions may be removed and destroyed during the winter, but this is too expensive to be practicable in ordinary cases.

Cross-fertilization of corn (pp. 316–337).

A large number of varieties of corn were planted May 5; after an interval of about 10 days the same kinds were again planted in an adjacent row. This was repeated, after a similar interval, a third and a fourth time. In this way, ripe pollen and receptive pistils (silk) were secured for crossing varieties that ordinarily mature at different times.

Owing, in part at least, to a lack of thorough cultivation "some varieties failed to germinate or perished later, and some were not used."

The plan of effecting the desired fertilization was as follows: When the tassel had attained its full growth and the pollen was about to be discharged it was inclosed in a paper or cloth sack. At first manilla bags were used, but they were found to be too stiff to handle and tie satisfactorily, and were injured by rains; they were therefore abandoned. Cloth sacks were found effective and satisfactory. Cotton cloth was selected the meshes of which were smaller than the diameter of the pollen grains; it therefore prevented the passage of the same. In order to test the efficiency of this cloth ears were inclosed in several cases, but no pollen introduced; in all such cases no grains at all were fertilized, thus proving that the cloth was an effectual barrier to the passage of the pollen. * * *

The ear just before the emergence of the silk was inclosed by similar cloth—a cylinder instead of a sack being used. * * *

The mode of applying the pollen was as follows: The sack over the tassel of the variety whose pollen was desired was carefully removed and carried to the ear to be fertilized. The cloth cylinder covering the latter was loosened below and lifted so as to expose the silk, on which the pollen was then copiously sprinkled by hand. The cloth cylinder was then readjusted and tied again. The sack was usually replaced over the tassel from which it was taken. The ear remained inclosed by the cloth not only until the silk was entirely withered and dead, but in the majority of cases until the grains were ripe and the ears removed from the stalk. * * *

It will be seen from the table and notes that 41 varieties were used in the experiments. The number of attempts to induce self-fertilization were 5, of which 3 were successful and 2 were unsuccessful.

In 3 cases fertilization was attempted with pollen from the same variety of corn, but produced by a different stalk. Of these but 1 was successful.

The number of cases of cross-fertilization attempted was 66, of which 39 were successful and 27 unsuccessful.

Of the successful crosses, 23 were made on the flint and dent varieties. Doubtful evidences of the effect were observed in 5 cases, and in the remaining 18 there were no visible effects whatever of the cross.

Three successful crosses were made on soft or table corn; of these 1 showed no signs of the cross, but the other 2 did show clearly the effects.

On the varieties of sweet-corn 10 successful crosses were made; six of them showed unmistakable evidence of effects in the ears, 2 were doubtful and 2 presented no visible evidence whatever.

The successful crosses made with the varieties of pop-corn were 3 in number. In 1 case there seemed to be no evidence of the effects. The other 2 ears were accidentally destroyed before they had been examined. * * *

Besides the five attempts to induce self-fertilization in plants of some varieties in the manner detailed above, another having the same end in view was carried out, as follows: Three stalks were inclosed a few days before the maturity of the pollen and protrusion of the silk, in three separate boxes 9 feet high, and 3 and 3½ feet respectively in the two horizontal dimensions. The east and west sides of each box were made of wood, with a window sash and glass inserted in the upper part. The north and south sides and top were covered with a continuous piece of cotton cloth, of the same quality as that used in the experiments explained above. The boxes were made "pollen tight." One box was not opened until the corn was dead at the end of the season. It was observed that when the pollen was ripe and discharged it fell in abundance on the protruding fresh silk. The stalk in the second box was artificially fertilized with its own pollen; that is, the box was entered and pollen taken from the tassel and placed by hand on the freshly exposed silk, the box being again made pollen tight. The stalk in the third box was supplied with pollen from stalks of the same variety grown outside of the box, applied in abundance by hand. Its tassel had been previously inclosed, preventing the possibility of self-fertilization. The stalks grew with apparent full health and vigor—but possibly might have been checked somewhat by their growing against the cloth covering at the top of the box, pushing it upward, and becoming themselves much bent. The result was the same in all the cases, namely, no successful fertilization—no grains at all appearing on the cob. Had but one stalk been experimented upon, namely, that in the first box, and no control plants been used as those in the second and third boxes, the conclusion might have been similar to that of Professor I. P. Roberts, of the Experiment Station at Ithaca, New York, in case of his experiment detailed in Studies in Practical Agriculture, Cornell University, 1887, p. 26, namely: That it pointed strongly toward the incapacity of the corn plant to close-fertilize; but cross-fertilization, although under similar conditions, was likewise unsuccessful. It seems proper, therefore, to regard this experiment as absolutely worthless, so far as regards positive evidence pointing toward the incapacity of corn to self-fertilize.

A list of the varieties planted for use in these experiments is given. The tabular record includes the name of the variety, date of inclosure of ear, date of first fertilization, name of variety from which pollen was obtained, result (whether an ear was produced or not), date of inclosure of tassel, and name of variety on which the pollen was used. There are also notes on the ears produced on each variety.

Germination of weed seeds (pp. 337–343).—This contains the tabular record of a series of tests made "to determine the number of seeds capable of germination in the soil at different depths [1–10 inches]."

Fungous parasites of weeds (pp. 344–346).—A list of 20 of the worst weeds of the State, with the number of parasites more or less injurious to each. The total number of parasites thus indicated is 32. "One hundred and thirteen species of fungi are at present known to inhabit the 98 weeds of the State considered especially troublesome.

KENTUCKY.

Kentucky Agricultural Experiment Station.

Department of the Agricultural and Mechanical College of Kentucky.

Location, Lexington. Director, M. A. Scovell, M. S.

FIRST ANNUAL REPORT, 1888.

Report of Director (pp. 5–36), (illustrated).—This includes brief statements regarding the history, equipment, organization, lines of work, and publications of the Station, together with a compilation by A. M. Peter, M. S., assistant chemist, of the results of chemical analyses made at the Station, but not published in its bulletins.

Historical (pp. 5, 6).—The Station was established by the Board of Trustees of the Agricultural and Mechanical College of Kentucky, in September, 1885, and M. A. Scovell was elected director. In 1886 the State legislature "designated the Station as the Kentucky Agricultural Experiment Station, passed an act controlling the sale of commercial fertilizers in the State, empowered the director of the Station to make all official analyses under the law, and authorized him to make all necessary rules and regulations for its proper enforcement." After the passage of the act of Congress of March 2, 1887, the Station was reorganized and placed under the management of a Board of Control, consisting of the executive committee of the Board of Trustees, the president of the college, and the director of the Station. The action of the Board of Control was, however, made subject to final review by the Board of Trustees. A farm of 48½ acres was purchased, the erection of a Station building provided for, and the working force enlarged.

Equipment (pp. 6–11).—The new Station building is described and illustrated. It is a two-story structure 70 by 54 feet, and contains offices, library, chemical laboratories, rooms for work in botany and entomology, lecture rooms, museum, etc.

The Station farm is situated about three-quarters of a mile from the college, and is divided into pasture, orchard, and experimental plats. There are a large brick dwelling-house and two barns on the farm.

Organization and work (pp. 11, 12).—"The officers of the Station include the director and chemist, two assistant chemists, an agriculturist, farm superintendent, practical horticulturist, and secretary and stenographer. The work has been almost entirely confined to chemical analyses and investigations and field experiments."

Publications (p. 12).—"Since the organization of the Station sixteen bulletins have been published, giving the results of the various experiments, under the following titles: (1) Do Fertilizers Affect the Quality of Tobacco? (2) Corn Fodder as a Food for Stock. (3) Milk. (4) Distillery Slops. (5) Analyses of Feeding Stuffs. (6) Clover. (7) Commercial Fertilizers. (8) Wheat Experiments. (9) Experiments with Potatoes. (10) Commercial Fertilizers. (11) Wheat Experiments. (12) Commercial Fertilizers. (13) Commercial Fertilizers. (14) Commercial Fertilizers. (15) Wheat Experiments. (16) Experiments with Potatoes. The editions of nearly all these bulletins are entirely exhausted, and as there is a constant demand for them they are reproduced in this report almost entire."

Analyses (pp. 13–36).—Notes and tabulated data for analyses of Kentucky blue-grass, English blue-grass, timothy, red clover, alfalfa, orchard grass, redtop, alsike clover, hominy waste, cotton-seed meal, thirty-nine samples of fertilizers, iron ore, sandstone, petroleum, molasses, tobacco, the stomach of a cow poisoned by tobacco, mineral waters, and a number of varieties of sorghum.

BULLETIN NO. 1.—EFFECT OF FERTILIZERS ON THE QUALITY OF TOBACCO, A. E. MENKE, D. SC. (pp. 36–38).—Tabulated data are given for experiments in which different fertilizers were applied to tobacco grown on "blue-grass" soil. The best grade of tobacco was produced on the plat where nitrate of potash and sulphate of lime were the fertilizers used.

BULLETIN NO. 2.—CORN FODDER AS FOOD FOR STOCK, M. A. SCOVELL, M. S. (pp. 38–42).—Tabulated data are given for analyses of corn stover made at the Station, which are compared with the results of similar analyses at the Stations in New Jersey, Connecticut, and Massachusetts.

BULLETIN NO. 4.—DISTILLERY SLOP, A. E. MENKE, D. SC., AND R. T. GUNN (pp. 43–49).—Tabulated data for analyses of distillery slop and a discussion of its value as a feeding stuff.

BULLETIN NO. 5.—ANALYSES OF FEEDING STUFFS (pp. 50–77).—This includes definitions of the terms commonly used in statements of the results of analyses of feeding stuffs and tabulated data for analyses of corn stover, clover hay, timothy hay, timothy and redtop, German millet, sugar-beets, orchard grass hay, redtop hay, blue-grass hay, and corn silage.

BULLETIN NO. 6.—CLOVER, A. E. MENKE, D. SC., AND H. F. HILLENMEYER (pp. 78–84).—An account is given of an experiment in which clover seed was sown on the surface of the ground at intervals of 10 days from February 2 to April 15, and was either covered or left uncovered. It was found that the seeds sown between February 2 and March 1 were covered by natural processes and almost all germinated. On the other hand those sown later were left exposed and did not germinate well.

In experiments with reference to the relative value of different-colored clover seeds the yellow seeds gave the best results.

BULLETIN NO. 7.—FERTILIZER ANALYSES, 1886 (pp. 84–88).—Tabulated results of analyses of 48 samples of commercial fertilizers, including superphosphates, complete fertilizers, and bone manures.

BULLETIN NO. 8.—EXPERIMENTS WITH WHEAT, 1886 (pp. 89–97).—Tabulated data and descriptive notes are given for a single year's test of 10 varieties of wheat. The best results were obtained with Martin's Amber, Diehl Mediterranean, and Extra Early Oakley. The wheat was planted in drills 18 inches apart, for the purpose of trying the effect of spring cultivation. The season was so wet as to be very unfavorable for the experiment and the result was inconclusive. Nitrate of soda, sulphate of ammonia, and superphosphate of lime, applied singly, caused the wheat to get an earlier and more vigorous start. The plat fertilized with sulphate of ammonia gave the best results. The bulletin also contains extracts from an article on smut by Professor W. H. Brewer, taken from the United States Census of 1880.

BULLETIN NO. 9.—EXPERIMENTS WITH POTATOES, 1886 (pp. 97–109).—These included a test of varieties and experiments with different amounts of seed, and with fertilizers. Descriptive notes and tabulated data are given for 19 varieties. The largest yields were given by Charter Oak, Burbank, White Star, Clarke's No. 1, Vanguard, Early Rose, Rochester Favorite, Empire State, and Pearl of Savoy. As regards quality as determined by the amount of dry matter, the best varieties were Charter Oak, Perfect Peach Blow, Early Rose, Rochester Favorite, Beauty of Hebron, Clarke's No. 1, Extra Early Vermont, and Burbank. A test of the keeping quality of the different varieties was made by analyzing samples of potatoes which had been stored in a warm cellar until early in February. In this test the best results were obtained from the Empire State, Charter Oak, Clarke's No. 1, Perfect Peach Blow, White Star, Triumph, Pearl of Savoy, Burbank, and Vanguard.

In the experiment with different amounts of seed, small and large tubers and two-eye pieces of Burbank potatoes were planted on tenth-acre plats. The results favored the planting of whole potatoes of large size. The smallest yield was from the two-eye pieces.

In the experiment with fertilizers, nitrate of soda, superphosphate of lime, and sulphate or chloride of potash in various combinations, "Mapes Complete Potato Manure," stable manure, "Homestead Tobacco Grower," and limestone dust were compared with no manure on 11 tenth-acre plats. The results indicate that the commercial fertilizers materially increased the yield. The limestone dust had no appreciable effect. The results of analyses of potatoes from the different plats are recorded.

BULLETIN NO. 10.—FERTILIZER ANALYSES, 1889 (pp. 109–114).—Tabulated results of analyses of 55 samples of commercial fertilizers.

BULLETIN NO. 11.—EXPERIMENTS WITH WHEAT, 1887 (pp. 115–126).—These include a test of varieties and experiments with methods of seeding and cultivation, with fertilizers, and in the treatment of seed to prevent smut. Tabulated data and descriptive notes are given for 15 varieties. The best yields were obtained with Mediterranean Hybrid, Diehl Mediterranean, Longberry (Nigger), German Emperor, Hicks, and Extra Early Oakley.

Extra Early Oakley wheat was sown broadcast and in drills at different depths and in different amounts per acre. The results are given in a table.

The experiment in the spring cultivation of wheat begun in 1886 was repeated in 1887. The results for the latter year, as tabulated, show a small difference in favor of the cultivated plats.

Results of an experiment with various fertilizers, as tabulated, were inconclusive. A sulphate-of-copper solution was successfully used in treating wheat seed to prevent smut. Solutions of lime and salt were comparatively ineffective.

BULLETIN NO. 12.—ADDITIONAL FERTILIZER ANALYSES, 1887 (pp. 127, 128).—Tabulated results of analyses of 8 samples of raw-bone manures and one sample of dissolved bone.

BULLETIN NO. 14.—COMMERCIAL FERTILIZERS, 1888 (pp. 128–141).—This contains accounts of the valuable ingredients of fertilizers and the sources from which they are obtained, explanations of the tabulated statements of analyses, and the tabulated results of analyses of 62 samples of commercial fertilizers.

BULLETIN NO. 15.—EXPERIMENTS WITH WHEAT, 1888 (pp. 142–153).—These include a test of varieties and experiments in spring cultivation and with fertilizers. Descriptive notes are given for 14 varieties and tabulated data for 24 varieties, together with a brief report on the milling qualities of 19 varieties. Best average results from those varieties which have been tested 3 years at the Station have been from Diehl Mediterranean, Extra Early Oakley, Hicks, and McGhee's White. The results of the experiment in spring cultivation, as tabulated, show a small difference in favor of the uncultivated plats. The experiment with fertilizers was inconclusive.

Bulletin No. 16.—Experiments with potatoes, 1888, M. A. Scovell, M. S., and A. M. Peter, M. S. (pp. 154–172).—These include a test of varieties and experiments with methods of cutting and planting and with fertilizers. Tabulated data are given for the yields of 65 varieties and for the quality of 61 varieties, as indicated by the amount of dry matter.

In an experiment in planting large and small tubers and two-eye pieces, by far the largest yield was obtained from the large whole potatoes, but this increase in yield was not sufficient to compensate for the increased outlay for seed. In 1886, however, the yield from the large potatoes used in a similar experiment was a profitable one. Results obtained in similar experiments at the Maryland Station are cited from Bulletin No. 2 of that Station.

In the experiment with fertilizers, acid phosphate, sulphate of potash, muriate of potash, and sulphate of ammonia, singly, two by two, and all three together were compared with no manure on 10 tenth-acre plats on which Early Rose potatoes were planted. The results, as tabulated, indicate that potash is the fertilizer needed on the soil of the Station farm, which is like that of a considerable portion of the blue-grass region of Kentucky, and is derived from the Lower Silurian limestones. This experiment also indicated that the potash compound may be profitably used on such soil. London purple was successfully applied to potato vines as an insecticide for the potato bug.

Legislation (pp. 174–181).—Under this head are given the full text of the act of Congress of March 2, 1887; of the State legislature approved February 20, 1888, assenting to the act of Congress; and of the State fertilizer law approved April 13, 1866.

MAINE.

Maine State College Agricultural Experiment Station.

Department of State College of Agriculture and the Mechanic Arts.

Location, Orono. Director, Whitman H. Jordan, M. S.

ANNUAL REPORT FOR 1888.

Report of Director (pp. 5–26).

The Maine legislature of 1885 passed an act locating at the college what was to be known as the Maine Fertilizer Control and Agricultural Experiment Station, appropriating to its support the sum of $5,000 annually. This Station was not placed under the control of the trustees of the college, but was intrusted to a board of managers, three of whom were to be appointed by the governor of the State, the others to be the secretary of the Board of Agriculture, and the professor of agriculture at the college.

This Station existed about 2½ years, and issued 20 bulletins and 3 reports, the former being published only in the leading papers of the State and the latter as a part of the Report of the Maine Board of Agriculture.

The work of this Station consisted of the inspection of commercial fertilizers and the conducting of such experiments and investigations as the remaining time and means allowed.

After the passage of the act of Congress of March 2, 1887, the Station was reorganized under the provisions of that act; but owing to delay in the appropriation bill by Congress the Station did not begin operations under its new management until February 16, 1888. The Board of Trustees of the college put the Station—

Into the immediate charge of an Experiment Station Council, constituted as follows: the president of the college, the director of the Station, the professor of agriculture, the professor of natural history, the Station veterinarian, and the Station horticulturist (when appointed).

At a subsequent meeting this council was enlarged by the addition of a committee of the trustees.

The work of the Station has been divided along the following general lines: (1) Cattle foods and feeding, and animal products; (2) fertilizers and crop production; (3) varieties of farm crops, agricultural botany, and entomology; (4) animal diseases; (5) horticulture; (6) agricultural meteorology and physics; (7) fertilizer inspection; (8) chemical analyses; (9) supervision of field and feeding experiments. From its foundation the Station had occupied rooms in the college buildings, but in February, 1887, arrangements were made—

For the erection of a building to contain the chemical laboratory, Station office, and director's room. This building, constructed of brick with granite trimmings, is now nearly ready for occupancy, and is believed to be well suited to the work for which it is intended. Its general appearance and plan are shown by the plates accompanying the report.

This building will be thoroughly equipped. The experiments with live stock have thus far been carried on in a barn belonging to the college.

Land necessary for field experiments has been set aside from the college farm and is already occupied, and the field experiments to which it is devoted include the use of small plats for fertilizer tests and tests of varieties, and of large areas on which different systems of crop production will be practiced for a series of years.

For feeding and dairy experiments the Station has purchased 8 thoroughbred cows (2 each of the Jerseys, Ayrshires, Holsteins, and Shorthorns), 6 thoroughbred steers (2 each of the Herefords, Holsteins, and Shorthorns), 12 pigs, and 6 sheep; also the necessary scales for weighing animals, rations, and milk; and an outfit of dairy apparatus.

Owing to the reorganization of the Station, comparatively little experimental work was done in 1888. This report is, therefore, largely devoted to articles which give general information regarding matters of interest and importance to farmers.

For instance, under the head of foods, quite an amount of space is occupied by explanations in regard to the composition and digestibility of cattle foods, and the basis, value, and use of the German feeding standards, and these subjects have been treated at so much length in response to a direct call for such information. It is proposed to treat other subjects in a similar manner, so that the Station reports may serve as books of reference. It will be noticed, also, that the main part of the matter given in the bulletins published in 1888 is reprinted here.

Experiments and investigations, the results of which are already published (pp. 17–23).—(1) *Wood ashes.*—The determination of the composition of ashes from different woods, and of those burned and kept under different conditions. (Report M. E. S.,* 1885–86, pp. 29–34.)

(2) *Manure residue.*—The determination of the value of manure residue from corn meal and cotton-seed meal, by the feeding of corn meal and cotton-seed meal with same amount of some kind of hay, and collection and analysis of fæces and urine during the two periods. (Report M. E. S., 1885–86, pp. 42–46.)

(3) *Digestion experiment.*—On digestibility of timothy hay fed to a sheep, with corn meal or cotton-seed meal, for 12 days; fæces collected for last 5 days. Digestibility of meal assumed from German averages. The feeding was carried on for three periods of 12 days each. (Report M. E. S., 1885–86, pp. 35–58.)

(4) *Digestion experiment.*—On digestibility of maize kernel fed in different forms. Weighed quantities of whole corn, corn meal, and corn-and-cob meal were fed to pigs, each for 12 days, and fæces collected for last 5. Three periods. (Report M. E. S., 1885–86, pp. 59–64.)

(5) *Feeding experiment.*—On the advantage of combining cotton-seed meal with corn meal in moderate grain ration fed to milch cows. The same weights of food were fed in three different periods, in first and third periods the grain ration being a mixture of cotton-seed meal and corn meal, and in the second period pure corn meal. Three cows used in experiment, each period of feeding being 4 weeks. During the last 2 weeks of each period a record was kept of the milk produced, and of the cream and butter, the milk being analyzed also. (Report M. E. S., 1885–86, pp. 65–72.)

(6) *Feeding experiment.*—Comparison of wheat straw and a nitrogenous grain ration with timothy hay and corn meal, as food for growing steers. Two lots of steers, 2 in each lot, same weights of hay and straw fed, and same weights of grain, only the lot eating straw received some cotton seed in place of part of corn meal fed to lot eating timothy. (Report M. E. S., 1885–86, pp. 73–76.)

(7) *Field experiment.*—The practical effect of different forms of phosphoric acid in crop production, also a complete commercial fertilizer against yard manure. Three plats in series were manured with each form of $P^2 O^5$, accompanied by a sufficient supply of ammonia and potash salts alone, 3 plats with no manure, and 3 plats with yard manure. (Report M. E. S., 1886–87, pp. 41–49.)

(8) *Field experiment.*—The use of partial as compared with complete fertilizer. The profitable quantity of fertilizers to use. Similar to experiment 7. (Report M. E. S., 1886–87, pp. 47–49.)

(9) *Field experiments.*—To stimulate habits of inquiry and observation, to render farmers more familiar with the composition of fertilizers, and to add something if possible to our stock of knowledge in regard to the profitable use of commercial fertilizers, bags containing different mixtures of fertilizing material were sent to farmers with directions for making experiments. The various combinations were $P_2 O_5$ and K_2O, and P_2O_5,K_2O, and N. (Report M. E. S., 1886–87, pp. 49–64; 1888, pp. 69–81.)

(10) *Digestion experiment.*—Digestibility of timothy hay. Seven hundred grams hay were fed to a stall for 12 days, fæces collected for last 5 days. Fæces and food analyzed. (Report M. E. S., 1886–87, pp. 72, 73.)

(11) *Digestion experiment.*—Digestibility of clover hay. Same as experiment 10, only 700 grams clover hay were fed. (Report M. E. S., pp. 74, 75.)

(12) *Digestion of oat straw.*—Same as experiments 10 and 11, only 350 grams oat straw were fed daily. (Report M. E. S., 1886–87, pp. 75, 76.)

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* M. E. S., for Maine Experiment Station.

(13) *Digestion experiment.*—Digestibility of potatoes, both raw and boiled. Three hundred and fifty grams oat straw used in experiment 12 and 1,000 grams raw potatoes were fed to two sheep for 12 days, fæces collected last 5 days. Digestibility of straw assumed to be as found in experiment 12; 300 grams timothy used in experiment 10, and 1,000 grams boiled potatoes fed to one sheep for 12 days. (Report M. E. S., 1886–87, pp. 47–79.)

(14) *Feeding experiment.*—Same as experiment No. 5. Four cows were used in experiment and in each period two cows received timothy and two clover hay; otherwise plan same as experiment No. 5. (Report M. E. S., 1886–87, pp. 84–89.)

(15) *Feeding experiment.*—The profitable quantity of food and the profitable combination of foods in feeding steers for growth. Ten steers about 18 months old, divided into five lots. Lot 1, maintenance ration, hay. Lot 2, ration for moderate growth, hay, hay and corn meal. Lot 3, ration for moderate growth, hay, corn meal and cotton-seed meal. Lot 4, ration for rapid growth, hay, corn meal, and cotton-seed meal. Lot 5, straw substituted for hay. (Report M. E. S., 1886–87, pp. 89–93.)

(16) *Feeding experiment.*—The comparative value of whole corn and corn meal for feeding hogs. Two lots of pigs were used, three in each lot; first period lot 1 fed whole corn, lot 2 fed same weight corn meal; second period lot 1 fed corn meal, lot 2 fed whole corn. In each period same quantity of potatoes and skim-milk fed each lot. (Report M. E. S., 1886–87, pp. 97–99.)

(17) *Feeding experiment.*—The comparative feeding value of corn meal and corn-and-cob meal for hogs. Two lots of pigs were used, three in each lot; lot 3 received corn meal, potatoes, and milk; and lot 4, a weight of corn-and-cob meal containing same amount of kernel as the pure meal of lot 3, and same amount of potatoes and milk. (Report M. E. S., 1886–87, pp. 99, 100.)

(18) *Feeding experiment.*—The relative feeding value of raw and boiled potatoes. Two lots of three pigs each were fed same weights of potatoes, corn meal, and skim-milk, only with one lot the potatoes were boiled before feeding. (Report M. E. S., 1886–87, pp. 100, 101.)

(19) *Feeding experiment.*—The profitable composition of rations for growing poultry. A pure corn ration was fed against a ration consisting of a mixture of corn and some highly nitrogenous material. Two lots of cockerels, of twelve each. (Report M. E. S., 1886–87, pp. 101–104.)

(20) *Dairy experiment.*—The effect of varying temperature at which milk is set for cream raising: (1) Upon volume of cream; (2) upon composition of cream; (3) upon quantity of cream to each pound of butter; (4) upon fat in skim-milk. Other minor points were considered. Equal weights of same milk were set at different temperatures; the milk, cream, and skim-milk were analyzed. (Report M. E. S., 1886–87, pp. 107–119.)

(21) *Available nitrogen.*—Relative value of organic nitrogen in different fertilizers. Treatment of fertilizers with an artificial pepsin solution, and determination of undissolved nitrogen. (Report M. E. S., 1886–87, pp. 124–126.)

(22) *Digestion methods.*—The comparison of artificial digestion of protein, with results obtained by experiments with animals; also errors for protein of natural method. Treatment of foods used in digestion experiments with animals with artificial solutions of pepsin and pancreas; and treatment of fæces with such solvents as will remove the "*Stoffwechselprodukte*" (metabolic products), and not act upon the undigested food residue. (Report M. E. S., 1886–87, pp. 127–135, and this report.)

(23) *Test of varieties.*—Test of comparative value of different varieties of oats. Equal areas were sown with the different varieties under similar conditions, and the main facts of growth, yield, and bushel weight recorded. (Report M. E. S., 1886–87, pp. 105, 106; 1888, pp. 126, 127.)

(24) *Test of varieties.*—Test of comparative value of different varieties of barley. Same as experiment No. 23. (Report M. E. S., 1886–87, p. 106; 1888, pp. 128, 129.)

(25) *Test of varieties.*—Test of comparative value of different varieties of potatoes. An equal number of hills were seeded alike, under similar conditions, with record of growth and yield. (Report M. E. S., 1886–87, pp. 104, 105; 1888, pp. 123–125.)

(26) *Digestion experiment.*—Determination of composition and digestibility of different species of grasses and other forage plants. Collected at same stage of growth, subsequent analysis, and digestion experiments. (Report M. E. S., 1888.)

(27) *Culture experiment.*—The effect of hilling potatoes as compared with flat culture. Equal areas of potatoes were cultivated under similar conditions, only certain plats hilled, and certain plats given flat culture, with both deep and shallow planting. (Report M. E. S., 1888.)

(28) *Feeding experiment.*—See experiment No. 16.

(29) *Feeding experiment.*—The economy of feeding grain to growing steers while at pasture. Two lots of steers were fed, one on grass alone and the other on grass and corn meal; the rations alternated between the two lots. (Failure.)

Experiments or investigations undertaken or planned (pp. 23–26).

(30) *Study of breeds.*—A study of the characteristics and economy of different breeds of cows for dairy purposes. The use of four breeds, two cows of each, Holstein, Shorthorn, Ayrshire, and Jersey; a record of the amount and composition of foods, the weight and composition of milk, weight and composition of cream, and weights of butter; also a study of physical characteristics of milk and chemical and physical properties of butter.

(31) *Study of breeds.*—Study of relative production of beef with different breeds. The use of three breeds, two steers of each, Hereford, Shorthorn, and Holstein, to be grown from calves under similar conditions and feeding.

(32) *Feeding experiment.*—The economical composition of a ration for beef production. The dividing of steers in experiment 31 into two lots, one steer of each breed in each lot, one lot to be fed a ration such as can be compounded without the purchase of highly nitrogenous foods, the other to receive an equal weight of food containing a certain proportion of cotton-seed (or linseed) meal.

(33) *Fodder investigation.*—A study of the relative feeding value of timothy, cut at different stages of growth. Determination of weights, composition, digestibility, and growth produced, of timothy from plats cut at different stages of growth. Piece divided into six plats, three cut when in bloom, and three cut about two weeks later.

(34) *Fodder investigation.*—The relative amounts and composition of dry matter produced by different varieties of corn grown for ensilage. The growing of the different varieties of corn on equal areas under similar condition of soil, manuring, and cultivation. Two acres divided into twelve equal plats, four plats being planted to each variety of corn, Southern White, common field corn, and sweet-corn.

(35) *Feeding experiment.*—The feeding value of ensilage as compared with hay. The feeding to milch cows and growing steers the same amounts of digestible material in ensilage and hay, the other parts of the ration being alike.

(36) *Feeding experiment.*—The determination of the actual maintenance ration. Feeding steers with hay; record to be kept of weight and composition of foods fed, change in weights of animals, and weights and composition of excretions.

(37) *Feeding experiment.*—The relative value of skim-milk and corn meal as foods for growing swine. The feeding to two lots of pigs, of two animals each, the same amounts of digestible material, to come more largely from skim-milk than in the other, a small amount of bone meal to be fed to each lot. Pigs from same litter.

(38) *Feeding experiment.*—The effect of a large amount of drink on the growth of pigs. The feeding to two lots of pigs, of two each, the same amounts of digestible material, in one case the amount of drink to satisfy the thirst of the animal, and in the other the animal to be induced to drink more than necessary.

(39) *Feeding experiment.*—The use of nitrogenous foods in the growing of pigs. The feeding of two lots of pigs on same amounts of digestible material, the ration to

be more nitrogenous in one case than in the other, drink and all other conditions to be similar.

(40) *Fertilizers, pot experiment.*—The study of the availability of different forms of phosphoric acid. The growing of plants in sand, different pots being manured with different forms of P_2O_5, all other elements of plant food being supplied in abundance, and conditions of temperature and moisture, being the same for all pots. Galvanized iron pots used.

(41) *Fertilizers, box experiment.*—Same as No. 40, only plants grown in boxes 3 feet square, set ground, no bottoms, and filled with ordinary soil.

(42) *Fertilizers, box experiment.*—A study of the availability for plant growth of different forms of nitrogenous material. (Same as No. 41.)

FERTILIZER INSPECTION (pp. 27–36).—This includes explanations regarding the ingredients and valuations of fertilizers; and a schedule of trade values of fertilizing ingredients for 1886, 1887, and 1888, adopted by several Stations, with explanations.

ANALYSES OF FERTILIZERS, J. M. BARTLETT, M. S., AND L. H. MERRILL, B. S. (pp. 37–63).—Here are given tables showing the history, analyses, and valuations of 85 samples of 38 brands of commercial fertilizers offered for sale in Maine in 1888, as well as of 3 samples of bone, 1 of sulphate of potash, and 5 of muck.

Muck.—The samples of muck varied greatly in the amounts of organic matter and manurial ingredients.

Compared with stable manure the average for nitrogen is nearly the same, but the mucks are inferior in the quantities of mineral compounds. It should not be forgotten that the ingredients of the stable manure are much more available than those of the mucks. Until the muck is composted we may believe that it will furnish but little food to a growing plant. If, however, by treatment with lime, or under the influence of the fermentation of the manure pile the nitrogen it contains is largely rendered available, the muck bed may be made a not insignificant source of plant food. The whole matter of its use turns upon the cost of getting it to the barn and from the barn to the field, as compared with what is saved by its use as an absorbent, plus the value of the small amount of plant food which it contains. The latter factor would not average over $2 per ton in the case of the 5 samples analyzed, reckoning the nitrogen, phosphoric acid, and potash at such prices as these ingredients would cost in coarse bone, raw South Carolina rock, and muriate of potash, and it is doubtful if these ingredients are as valuable in the muck as in the materials named. This, at least, is plainly taught by these analyses—that each muck bed must be judged upon its own merits.

EXPERIMENTS WITH FERTILIZERS, W. BALENTINE, M. S. (pp. 63–81).—*Box experiments with fertilizers.—Action of crude phosphate* (pp. 64–66).

In 1887 boxes 3 feet square and 1 foot high, without bottoms, were procured and set in the earth in the open field. In the spring of 1888 the boxes were filled with loam that had been piled up in a heap and shoveled over many times in order to make it as uniform as possible. One set of these boxes was left without the application of fertilizing material of any kind. The remaining boxes each received an application of 37.5 grams of muriate of potash and 50 grams of sulphate of ammonia. This amount was added, that there should be no deficiency in potash or nitrogen to interfere with the success of the experiment. To one set of three boxes which had received the above application of muriate of potash and sulphate of ammonia 37.5 grams of dissolved bone-black was added to each box. To another set of three boxes there was added to each box 41.1 grams of finely ground South Carolina rock; to another set of three boxes was added 31.2 grams of finely ground Aruba phosphate; to another set, 42 grams of finely ground Caribbean Sea guano; to another set, 30.7 grams of powdered Canadian apatite; to another set, 33.5 grams of finely ground Vivorella phosphate; and a set of two was left without the addition of any phosphatic material.

The dissolved bone-black was applied at the rate of about 400 pounds to the acre and carried 16 per cent of soluble phosphoric acid. The application of crude phosphatic material was arranged so that the total phosphoric acid in the crude phosphate should be double the amount of soluble phosphoric acid in the dissolved bone-black. The fertilizing material was evenly mixed with 4 inches of the surface soil, and then in each box 260 oat kernels were planted. The boxes were watered with rain-water whenever they needed it. Below is given a table showing the analyses of the phosphatic materials used in the experiment, and another table showing the results of the experiment.

Phosphatic fertilizers used.

Name of phosphate.	Total phosphoric acid.	Insoluble phosphoric acid.	Available phosphoric acid.
	per cent.	*per cent.*	*per cent.*
Dissolved bone-black	....	....	16.00
South Carolina rock, fine ground	28.64	24.17	4.47
Aruba, fine ground	35.51	32.86	2.65
Caribbean Sea guano, fine ground	28.58	20.98	7.60
Apatite, fine ground	39.12	38.51	0.71
Vivorella, fine ground	35.88	26.34	9.54

Yields of oats and straw.

Fertilizers.	Number of box.	Yield of grain.	Yield of straw.	Average yield of grain per box.	Average yield of straw per box.	Average yield of grain and straw per box.	Average yield of boxes in excess of the average of the boxes to which muriate of potash and sulphate of ammonia alone were applied.
		grams.	*grams.*	*grams.*	*grams.*	*grams.*	*grams.*
Nothing	1	163.1	234	159.1	232.3	391.4	16.0
	2	154.9	203				
	3	159.3	260				
Dissolved bone-black, 37.5 grams	4	304.6	500	242.4	403.0	645.4	270.0
Muriate of potash, 37.5 grams	5	242.6	409				
Sulphate of ammonia, 50 grams	6	180.0	300				
South Carolina rock, 41.1 grams	7	219.1	302	209.6	313.7	523.3	197.9
Muriate of potash, 37.5 grams	8	196.1	350				
Sulphate of ammonia, 50 grams	9	213.7	289				
Aruba, 31.2 grams	10	257.8	389	203.4	326.0	529.4	204.0
Muriate of potash, 37.5 grams	11	152.8	339				
Sulphate of ammonia, 50 grams	12	199.7	250				
Caribbean Sea guano, 42 grams	13	176.7	352	209.7	376.3	586.0	210.6
Muriate of potash, 37.5 grams	14	382.2	400				
Sulphate of ammonia, 50 grams	15	*70.2	377				
Canadian apatite, 30.7 grams	18	129.5	239	139 4	269.0	408.4	33.0
Muriate of potash, 37.5 grams	19	137.1	289				
Sulphate of ammonia, 50 grams	20	151.5	279				
Vivorella, 33.5 grams	21	250.1	385	205.1	340.7	545.8	170.4
Muriate of potash, 37.5 grams	22	212.6	350				
Sulphate of ammonia, 50 grams	23	152.6	287				
Muriate of potash, 37.5 grams	25	142.9	229	157.4	218.0	375.4	....
Sulphate of ammonia, 50 grams	26	171.8	207				

*The low yield of grain obtained from box 15 probably results from a loss of grain from shelling.

This experiment leaves little room to doubt that all of the crude phosphates, except the apatite, caused a large increase in the crop. In the case of the Vivorella there was an increase of 45 per cent over the boxes which were fertilized with muriate of potash and sulphate of ammonia alone. With the Caribbean Sea guano the increase amounted to 59 per cent. The Aruba gave an increase of 54 per cent, and the South Carolina rock 52 per cent.

These experiments in boxes will be continued and pot experiments added, in which the only source of phosphoric acid will be the crude phosphates.

It will be observed that the variations in the duplicate trials were very wide, notwithstanding the care taken to make the soil in the boxes as uniform as possible. Thus in the three boxes with dissolved bone-black the range was from 180 to 305 grams of oats, and with the Vivorella phosphate from 153 to 250 grams, while with the Caribbean Sea guano in box 13 the yield of oats was 177, and in box 14, 382 grams, or more than double. The yields of straw were somewhat less variable. The variations in the proportion of grain to straw were very wide indeed. The yield of both grain and straw was greater with no fertilizer than with the mixture of muriate of potash and sulphate of ammonia.

Field experiments with fertilizers by the Station (pp. 67–69).—In 1886 the Station instituted a series of field experiments, with the object of gaining information as to the comparative value of phosphoric acid in its various forms available for use; the use of a partial as compared with a complete fertilizer; the relative profits resulting from the use of different quantities of fertilizers; and the comparative results from the use of stable manure and commercial fertilizers.

The field selected was a clayey loam adapted to grass and grain. The field was divided into thirty-six plats, arranged in two tiers of eighteen plats each. The plats extended east and west and were 8 rods long by 1 rod wide. The plats were separated by a strip of land 8 feet wide, in which was a ditch deep enough to remove all surface water. To diminish the errors due to inequalities in the field three plats in different portions of the field received the same treatment. In 1886 the land was sown to oats; in 1887 oats were sown again, and the ground seeded to grass; and in 1888 a crop of hay was taken off.

During the years 1886 and 1887 the field received fertilizers in the proportions indicated in the following tables. There was no application of manure of any kind in 1888. The following tables give the average yield in grain and hay of three plats receiving the same treatment.

Methods of manuring.

TABLE I.

Kind of fertilizer.	Fertilizer per acre.	Average yield of oats per plat, 1886.	Average yield of oats per plat, 1887.	Average yield of hay per plat, 1888.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
Nothing	....	83.5	40	128.3
Dissolved bone-black	400	124.3	58	121.7
Muriate of potash	100			
Sulphate of ammonia	200			
Fine-ground bone	360	114.3	47.8	140
Muriate of potash	100			
Sulphate of ammonia	140			
Fine-ground South Carolina rock	300	108.3	53.2	128.3
Muriate of potash	100			
Sulphate of ammonia	200			
Muriate of potash	100	96.8	52.6	116.7
Sulphate of ammonia	200			
Stable manure	40,000	110.8	57	205

TABLE II.

Nothing	....	78.7	42.3	81.7
Dissolved bone-black	400	82.8	42.1	108.3
Do	400	81.5	36.6	103.3
Muriate of potash	100			
Dissolved bone-black	200	86.3	45	103.3
Muriate of potash	50			
Sulphate of ammonia	60			
Dissolved bone-black	300	103.5	42.9	88.3
Muriate of potash	100			
Sulphate of ammonia	120			
Dissolved bone-black	400	102	60.7	118.7
Muriate of potash	150			
Sulphate of ammonia	180			

It will be noticed from the results of these experiments given in Table I, that dissolved bone-black, with potash and ammonia salts, give the highest yield of grain, fine-ground bone standing next, while fine-ground South Carolina rock and stable manure produce about the same results. In 1888, without the further addition of manure, the stable manure stands far ahead of the others in its yield of hay, while the fine-ground bone stands next.

In the experiment with partial and complete fertilizers, the results of which are given in Table II, those plats which were fertilized with the complete fertilizer gave the largest yield in grain; and while the heaviest application does not seem to be necessary to produce the maximum yield of grain the first year, the heaviest application is felt in increased yield in the hay crop.

For some unaccountable reason the medium application of the complete fertilizer fails to increase the yield of the grain the second year, and the yield of hay the third year is correspondingly low.

Field experiments with fertilizers by farmers (pp. 69–81).—In the spring of 1886 the Station sent to farmers located in different parts of the State experimental sets of fertilizers, which were to be used according to directions given by the Station, the results of the experiments to be reported to the Station.

The objects were: to stimulate habits of inquiry and observation; to render farmers more familiar with the composition of fertilizers; and to add something, if possible, to our stock of knowledge in regard to the profitable use of commercial fertilizers. * * *

Fourteen farmers undertook experiments. With six of these the work resulted in utter failure, in most cases due to a drought. * * * Eight carried their experiments through successfully, and the results were reported in the Station Report for 1886–87. In 1887 experimental sets were again sent out to various farmers, ten of whom have reported their results to the Station. These reports are presented in tables. * * *

It is gratifying to be able to state that the experimenters were painstaking in their efforts to follow directions, and that where the experiments escaped unavoidable misfortunes the results were satisfactory, in some cases highly so.

The sets of fertilizers consisted each of eight bags, containing the materials stated below: bag 2, dissolved bone-black 20 pounds; bag 3, dissolved bone-black 20 pounds, muriate of potash 5 pounds; bag 4, dissolved bone-black 20 pounds, muriate of potash 5 pounds, sulphate of ammonia 5 pounds; bag 5, fine-ground bone 20 pounds; bag 7 was same as bag 2; bag 8 was same as bag 3; bag 9 was same as bag 4; and bag 10 was same as bag 5.

The plats were one-twentieth of an acre each. The crops were potatoes, beans, barley, and corn. The season was in general unfavorable and yields were small.

In these experiments the complete fertilizer, or bag No. 4, produced the largest crop. In three experiments none of the fertilizers produced gains large enough to pay for the fertilizers. In seven experiments bag No. 4 caused gains large enough to pay for the fertilizers. In one case, that of the experiment by Mr. Shaw, bag No. 3 was the most profitable fertilizer.

In general the complete fertilizers are the most profitable. There are a few cases in which partial fertilizers are more economical for the time being.

FEEDING STUFFS AND FEEDING, W. H. JORDAN, M. S. (pp. 81–122).—This includes (1) general explanations; (2) fodder analyses; (3) digestion experiments with sheep; (4) experiment on whole corn *vs.* corn meal as food for swine; (5) a discussion of the subject of compounding rations for farm animals, with tables of composition and digestibility of American feeding stuffs, and suggestions regarding methods of computing rations.

General explanations (pp. 81–85).

The general object of the analyses and experiments which have been undertaken during 1887 and 1888 was to make progress in ascertaining the comparative composition and digestibility of the cattle foods that are available for use by Maine farmers, and to test in a practical manner the efficiency and economy of certain combinations of food ingredients in the production of milk and meat.

The composition of some of the principal American cattle foods is quite well known, but if we except timothy and the clovers only a few analyses have been made of our hay-producing plants, and extremely few determinations of their digestibility. We have quite generally assumed that our fodders have the average digestibility given in the German tables, but this is probably not always correct, because our cattle foods are grown under conditions of climate and cultivation different from those of Europe. Further study of the digestibility of our fodder plants is therefore very desirable.

Fodder analyses (pp. 85–90).—In 1887 all the species of hay-producing plants growing on the college farm which could be obtained unmixed in sufficient quantity for analyses and digestion experiments, were gathered, carefully dried, and stored. With one exception the samples for analysis were selected while the plants were in full bloom, *i. e.* during the first ten days of July. The table following gives the composition of the air-dried fodders:

Table of fodder analyses.

Station No.	Species.	Stage of growth.	In 100 parts of air-dry substance.						In 100 parts of water-free substance.				
			Water.	Ash.	Protein.	Crude fiber.	Nitrogen-free extract.	Fats.	Ash.	Protein.	Crude fiber.	Nitrogen-free extract.	Fats.
XLI	Alsike clover (*Trifolium hybridum*).	In full bloom.	12.55	7.86	12.69	27.86	35.63	3.41	8.99	14.51	31.86	40.74	3.90
XLII	White clover (*Trifolium repens*).	In bloom for some time.	12.39	7.42	15.12	24.91	36.49	3.67	8.47	17.26	28.43	41.65	4.19
XLIII	Blue joint (*Calamagrostis canadensis*).	Cut late in July.	8.62	5.46	9.19	33.10	40.81	2.82	5.97	10.06	36.22	44.66	3.09
XL	Orchard grass (*Dactylis glomerata*).	Past bloom 7 to 10 days.	10.95	6.25	7.50	33.02	39.25	3.03	7.02	8.42	37.08	44.08	3.40
L	Redtop (*Agrostis vulgaris*).	In full bloom	11.60	4.47	8.56	27.38	44.78	3.21	5.06	9.69	30.98	50.64	3.63
XLIV	Timothy (*Phleum pratense*).	....do	8.32	4.20	7.50	29.94	46.74	3.30	4.58	8.18	32.66	50.98	3.60
LI	....do................	Somewhat past bloom.	12.60	4.52	6.85	28.05	44.84	3.14	5.17	7.84	32.10	51.30	3.59
XLV	Wild oat grass (*Danthonia spicata*).	In bloom	8.33	3.49	6.87	31.26	47.38	2.67	3.81	7.49	34.10	51.74	2.86
XXXIX	Witch grass (*Triticum repens*).	....do	10.85	4.83	8.50	33.94	38.52	3.36	5.41	9.53	38.07	43.21	3.78
XLVI	Buttercup (*Ranunculus acris*).	In full bloom.	10.43	6.01	9.06	30.44	40.71	3.35	6.71	10.11	33.97	45.47	3.74
XLVII	White weed, Daisy, (*Chrysanthemum Leucanthemum*).	....do	9.63	6.85	8.44	29.00	41.72	4.36	7.58	9.34	32.09	46.17	4.82

From the above analyses it is not apparent that wild oat grass, blue joint, buttercup, and white-weed have a composition inferior to the more highly prized timothy and redtop; in fact the former plants are more nitrogenous than the latter.

The popular impression is different, nevertheless, and if farmers are correct in their conclusions we must look further than the ordinary analysis of a fodder in order to learn its feeding value, for most certainly stock feeders are not willing to allow that blue joint is more valuable than good upland grasses like timothy and redtop, as the analyses seem to show. We need more information than is given by the figures of an ordinary table of fodder analyses.

We should remember that in estimating protein by the formula N×6.25 we learn nothing of the character of the nitrogen compounds in different feeding stuffs, that the nitrogen-free extract is determined by difference, with no knowledge whether the amounts present of the more valuable carbohydrates like starch and sugar are relatively the same in all, and that the nutrition to be derived from a food depends as much upon its digestibility as upon its composition. It may be that after we learn all that we can on these points we shall come to the conclusion that farmers are very much influenced by the palatableness of a food in forming their opinions of its value, and it may be that some of our feeding stuffs, commonly regarded as inferior, simply need to be rendered palatable in order to become efficient cattle foods. We have no evidence showing that fodders are necessarily nutritious in proportion as they are relished by cattle. In fact the qualities which render a cattle food palatable have no direct connection with its capacity for sustaining animal life.

Careful study of the composition of the samples analyzed was made with especial reference to two points: (1) the amount of non-albuminoid material usually reckoned as part of the protein; (2) the composition of the nitrogen-free extract, so far as it can be learned by the direct determination of the sugars, starch, and gums. The albuminoid nitrogen was determined in nine of the eleven samples. The results are given in a table, which shows the comparison of total albuminoid and non-albuminoid nitrogen in 100 parts of the air-dried substance and of the total nitrogenous material in albuminoid form.

So far as we can judge by these determinations there were no marked differences in the nitrogenous compounds of these fodders, but it is possible for the protein of one fodder to be essentially unlike that of another, without this being shown by the mere separation of the albuminoid from the non-albuminoid (amide) nitrogen.

Composition of the nitrogen-free extract.

As before stated, the non-nitrogenous part of fodders, excluding the crude fiber and fats, is made up of quite a variety of compounds. Among these are the sugars and starch, of whose composition and nutritive properties we have definite knowledge. The gums are also included in this class of compounds, and as they, like starch, are inverted* to sugar by the action of an acid, it is fair to suppose that they, like starch, are changed to sugar in the process of digestion, and that they have a value in nutrition very similar to starch. Beyond the compounds mentioned, the nitrogen-free extract is, in the case of fodder plants, made up of substances of which we have very little definite knowledge. Enough is known, however, to make it reasonably certain that the carbohydrates (sugar, starch, and gums) are the most valuable part of the non-nitrogenous compounds of a hay, the fats excepted, and therefore that the larger the percentage of the nitrogen-free extract, which exists as carbohydrates, the more valuable the fodder, other things being equal. Consequently it is reasonably certain that the nitrogen-free extract of the grains has a greater nutritive value than that of the coarse fodders, because in the former case it is made up almost wholly of starch and the sugars.

For some of these fodders the attempt was made to ascertain the percentages of the more valuable carbohydrate material, which, after the ordinary percentage of crude fiber is taken out, exists as sugars, starch, and other compounds, which may be converted into sugar. The following table gives the percentages of sugars and starch in fodders. The term starch is used to include all material not sugars—that is, inverted by treatment with an acid. The methods employed in the determination of the sugars and starch are given in the report of the chemist, p. 207.

Nitrogen-free extract.

Station No.	Species.	In 100 parts water-free substance.						Total nitrogen-free extract as sugar and starch.
		Total nitrogen-free extract.	Sucrose.	Glucose.	Starch.	Total sugars and starch.	Nitrogen-free extract not sugars and starch.	
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
XLI	Alsike clover	40.74	1.49	3.09	10.64	15.22	25.52	37.36
XLII	White clover	41.65	.39	2.73	15.77	18.89	22.76	45.35
XLIII	Blue joint	44.66	2.23	3.53	14.49	20.25	24.44	45.34
XL	Orchard grass	44.08	1.54	4.05	16.53	22.12	21.96	50.18
L	Redtop	50.64	3.14	4.25	16.58	23.95	26.69	47.29
XLIV	Timothy	50.98	3.70	6.76	16.17	26.63	24.35	52.24
LI	....do	51.30	3.25	6.48	14.92	24.65	26.65	48.06
XLV	Wild oat grass	51.74	1.78	3.76	17.46	23.00	28.74	44.46
XXXIX	Witch grass	43.21	2.57	5.09	16.66	24.32	18.89	56.29
XLVI	Butter cup	45.47	.60	4.65	9.15	14.40	31.07	31.66
XLVII	White-weed	46.17	.79	4.39	10.77	15.95	30.22	34.54

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*They are partly inverted, *i. e.* are decomposed, and sugars and acids are formed.

The above figures show that the true carbohydrates form a much larger part of the nitrogen-free extract of some plants than of others. For instance, the white-weed has nine-tenths as much non-nitrogenous material as the timothy (No. XLIV), but of sugar the latter has twice as much, and of starch one and a half times as much as the former. In other words, more of the nitrogen-free extract of the white-weed consists of compounds of which we have some reason to suspect a nutritive value inferior to starch and sugar. Just what these compounds are in composition and in nutritive value we do not know. They form in these instances from a fifth to a quarter of the dry substance of the plant, and in general constitute an unknown factor in the compounding of rations involving the use of coarse fodders.

Digestion experiments (pp. 90–100).

The digestibility of these fodders was studied through digestion experiments with sheep and by treating them with artificial solutions of pepsin and pancreas.

Experiments with sheep (pp. 91–97).—These were made with sheep, one being used for each of eleven experiments with the grasses and other forage plants, of which analyses were given above.

The animals used were full-grown wethers in all cases. They were confined during the time the experimental rations were fed, in stalls large enough to allow comfortable lying down, but small enough to oblige the animal to feed in such a way as to prevent loss. The feed boxes were zinc-lined, and projected up around the head in front and at the sides so that none of the finely cut fodder could easily be scattered out. The fæces were collected in rubber-lined bags closely attached to the animal by a light leather harness, and any loss of either fodder or dung could easily be detected.

The feeding period with each food was 12 days, during the last 5 of which the fæces were collected, the preliminary feeding of the first 7 days being considered necessary to entirely free the digestive apparatus from any residue of former food. Fortunately the rations were completely consumed, except in two instances where the amounts uneaten were too small to materially affect the results. The fæces were collected twice each day, weighed on a balance sensitive to one-half gram, and from the whole amount, carefully mixed, one-tenth was taken and dried for analysis.

The data needed for calculating the co-efficients of digestibility are: the composition of the foods eaten; the composition of the fæces; the weight of food eaten and dung excreted.

The composition of the fodders has already been given. That of the fæces is given in detail.

Tables are given showing in detail the composition of the fæces, the weights of the food eaten, and of the fæces. From these data calculations are made of the weight of each ingredient of each feeding stuff eaten, and the weight left undigested, from which the total amounts digested and the percentages digested (co-efficients of digestibility) of each are calculated. The following selections from the detailed table will serve for illustration:

Calculations of the digestibility.

Table.	Dry substance.	Organic matter.	Ash.	Protein.	Crude fiber.	Nitrogen-free extract.	Fats.
XLI—Alsike clover:							
Total fed, 700 grams daily	612. 1	557	55. 1	88. 8	195	249. 4	23. 9
Total excreted, 924.8 grams daily	233. 4	207. 5	25. 9	32	95. 5	64. 5	15. 5
Total digested	378. 7	349. 5	29. 2	56. 8	99. 5	184. 9	8 4
Per cent digested	61. 9	62. 7	53	64	51	74. 1	35. 1
XL—Orchard grass:							
Total fed, 700 grams daily	623. 3	579. 6	43. 7	52. 5	230. 9	274. 8	21. 1
Total excreted, 818.6 grams daily	284. 3	255. 9	28. 4	21. 8	98. 2	125. 5	10. 3
Total digested	339	323. 7	15. 3	30. 7	132. 7	149. 3	10. 8
Per cent digested	54. 4	55. 8	35	58. 5	57. 5	54. 4	51. 2
XLVI—Buttercup:							
Total fed, 700 grams daily	627	585	42	63. 4	213	285. 1	23. 5
Total excreted, 777.4 grams daily	275. 5	253. 7	21. 8	26. 7	125. 4	94. 3	7. 2
Total digested	351. 5	331. 3	20. 2	35. 7	87. 6	190. 8	16. 3
Per cent digested	56. 1	56. 6	48. 1	56. 3	41. 1	66. 9	69. 7

The co-efficients of digestibility thus found are arranged in the following table:

Co-efficients of digestibility.

Station No.	Species.	Dry substance.	Organic matter.	Ash.	Protein.	Crude fiber.	Nitrogen-free extract.	Fats.
XLI	Alsike clover	61. 9	62. 7	53	64	51	74. 1	35. 1
XLII	White clover	66	66 6	58. 5	73. 2	60. 6	69. 5	50. 6
XLIII	Blue joint	39. 9	41. 8	10	56. 5	36. 5	43. 2	37
XL	Orchard grass	54. 4	55. 8	35	58. 5	57. 5	54. 4	51. 2
L	Redtop	57. 6	59. 3	24. 3	60. 4	61. 2	59. 1	44. 2
XLIV	Timothy	65. 7	66. 8	41. 8	60. 4	62. 1	71. 8	51. 5
LI	Timothy	54. 1	55. 5	28	44. 5	51. 7	61	34. 6
XLV	Wild oat grass	59. 6	61. 2	17. 1	48. 6	65. 1	62. 1	38. 2
XXXIX	Witch grass	59. 9	61	40. 3	64. 2	67. 6	62. 1	60
XLVI	Buttercup	56. 1	56. 6	48. 1	56. 3	41. 1	66. 9	69. 7
XLVII	White-weed	57. 8	58. 3	52	58. 4	45. 5	66. 7	62
	Previous experiments.							
XXIV	* Alsike clover	54. 9	56. 2	....	55. 5	46. 2	64. 1	53. 2
XIV	† Timothy	....	59. 3	....	42. 1	52	65. 7	47. 6
XXIII	* Timothy	51. 6	52. 4	....	45. 2	42. 8	58. 9	55
XXVII	* Oat straw	50. 3	52	....	?	57. 6	53. 2	38. 3

* See Maine Station Annual Report, 1886–87. † Ibid, 1885–86.

In order to see more closely the differences in the digestible material of the several feeding stuffs we must construct a table showing the actual pounds of the various ingredients digested out of 100 pounds of the food. This is done by multiplying the pounds of each ingredient in 100 pounds of the food by the percentage (or co-efficient) of digestibility.

Quantities of nutrients digested from 100 pounds air-dry feeding stuff.

Station No.	Kinds of feeding stuffs.	Amounts digested from 100 pounds.				
		Total organic matter.	Protein.	Crude fiber.	Nitrogen-free extract.	Fats.
XXIV	Alsike clover	46.4	5.58	14.03	25.1	1.58
XLI	...do	49.9	8.12	14.2	26.4	1.20
XLII	White clover	54.8	12.85	13.68	25.97	2.39
XLIII	Blue joint	36.3	5.75	12.83	16.54	1.15
XL	Orchard grass	46.2	3.38	18.98	21.35	1.55
XXVII	Oat straw	44.9	?	21.85	22.3	1.16
XIV	Timothy	50.4	2.95	15.9	25.7	1.12
XXIII	....do	44.5	2.68	12.36	27.9	1.47
XLIV	....do	58.4	4.53	18.6	33.5	1.70
LI	....do	46	3.05	14.50	27.3	1.08
XLV	Wild oat grass	54	3.33	20.35	29.42	1.55
XXXIX	Witch grass	52.4	5.53	20.28	24.72	1.89
XLVI	Buttercup	48.5	5.43	12.03	28.29	3.07
XLVII	White-weed	50.4	4.87	14.15	28.57	2.54

Digestibility of nitrogen-free extract (pp. 98–100).

With a part of these fodders an attempt has been made to ascertain the digestibility of the more valuable carbohydrate material, viz., the sugars and starch and other compounds that by treatment with an acid are changed to sugar, crude fiber excepted. In order to compare the digestibility of these compounds with that of the total nitrogen-free extract, determinations of the sugars, starch and other non-nitrogenous material capable of inversion to sugar have been made in the fæces from several of the fodders, by a method exactly similar to that used for the hay.

Tables are given showing the percentages of starch in the fæces, and a comparison of the calculated digestibility of the carbohydrates with that of the total nitrogen-free extract. The term starch is intended to include all material, not sugar, that is inverted by the treatment with an acid. The table herewith gives results.

Nitrogen-free extract.

Station No.	Species.	Fed in one day.			Excreted in one day.			Digested in one day.			Digested from 100 parts fed of—		
		Sugar and starch.	Not sugar and starch.	Total.	Starch.	Not starch.	Total.	Sugar and starch.	Not sugar and starch.	Total.	Sugar and starch.	Not sugar and starch.	Total.
XLI	Alsike clover	93.1	156.2	249.3	15.0	49.5	64.5	78.1	106.7	184.8	85.9	68.3	74.1
XLII	White clover	115.8	139.5	255.3	28.7	49.1	77.8	87.1	90.4	177.5	75.2	64.8	69.5
XLIII	Blue joint	129.5	156.1	285.6	41.2	120.9	162.1	88.3	35.2	123.5	68.2	22.5	43.2
XL	Orchard grass	137.9	136.9	274.8	29.8	95.7	125.5	108.1	41.2	149.3	78.4	30.1	54.4
L	Redtop	147.7	164.6	312.3	32.5	95.1	127.6	115.2	69.5	184.7	78.0	42.2	59.1
XLIV	Timothy	170.9	156.3	327.2	25.1	67.1	92.2	145.8	89.2	235.0	85.3	57.1	71.8
LI	Timothy	150.8	163.0	313.8	32.7	89.5	122.2	118.1	73.5	191.6	78.4	45.1	61.0
XLV	Wild oat grass	147.6	184.4	332.0	33.2	92.6	125.8	114.4	91.8	206.2	77.5	49.7	62.1
XXXIX	Witch grass	151.8	117.9	269.6	29.9	72.3	102.2	121.9	45.6	167.5	80.6	38.7	62.1
XLVI	Buttercup	90.3	194.8	285.1	16.5	77.8	94.3	73.8	117.0	190.8	81.7	60.0	66.9
XLVII	White-weed	100.9	191.2	292.1	15.1	82.1	97.2	85.8	109.1	194.9	85.1	57.1	66.7

The above figures show that sugar, starch, and other compounds that are inverted to sugar by the action of an acid are found in larger quantity in some fodders than in others, in proportion to the total non-nitrogenous material, and, moreover, that these carbohydrates whose value as nutrients is well established constitute the most digestible part of the total nitrogen-free extract. These facts seem to explain in part why the bare statement of the analysis of a fodder as given in fodder tables does not constitute a definite measure of its value.

SUMMARY.

Some of the practical lessons to be drawn from the facts previously presented are summarized below:

(1) The upland grasses,* so far as analyzed, do not differ greatly in composition.

(2) The different species of upland grasses were found to differ very little from one another and from alsike clover, in digestibility. The blue joint, in the one experiment made, had a low comparative rate of digestibility.

(3) While the total amount of dry substance digested out of 100 pounds of the hay from the true grasses, such as timothy, witch grass, etc., and from alsike clover, was very nearly the same in all cases, the character of the material from the clover differed materially from that digested out of the grasses, being much more nitrogenous, and therefore better adapted than the grasses to the nutrition of an animal forming albuminoids rapidly, such as a milch cow or a young, growing animal.

(4) The fodders proved to be quite unlike in the percentages of sugar and starch which they contained, and which were digestible. The cases observed so far are too few to allow general conclusions, but there seems to be good reason for the assertion that the analyses of our fodders would much more fully give a measure of nutritive value if they showed what are the ingredients of the non-nitrogenous portion of the plant. For instance, the white-weed has as much non-nitrogenous material as the timothy (XLIV), 31 per cent of this being sugar and starch in one case and 52 per cent in the other. Any analysis that stops short of showing these facts fails to give data that are important in judging of nutritive value.

Whole corn vs. corn meal for swine (pp. 101, 102).—On pages 97 and 98 of the report of this Station for 1886–87 are given the results of a feeding experiment with whole corn against corn meal, which shows no difference in the feeding value of the two foods. This experiment was repeated with somewhat older animals, under very similar conditions.

A lot of Western corn was purchased, one-half of which was ground. Six pigs of quite uniform quality and size were selected from the same litter, and at the time the experiment was begun they were about five months old. They were divided into two lots, as equal as possible in size and quality, and were fed 84 days. The first period of feeding occupied 40 days and the last 44. In the first period lot 3 was fed 12 pounds of meal and lot 4, 12 pounds of whole corn. * * * In the second period this order was reversed, lot 3 getting the whole corn and lot 4 the meal, the daily ration of each being at the same time increased to 18 pounds. The two lots of pigs gained as shown in the following table:

Period 1.	Meal, lot 3.	Whole corn, lot 4.	Period 2.	Meal, lot 4.	Whole corn, lot 3.
	Pounds.	*Pounds.*		*Pounds.*	*Pounds.*
Weight October 9	511	478	Weight November 17	616	612
Weight November 17	616	612	Weight December 31	763	749
Gain in 40 days	105	134	Gain in 44 days	147	137

	Pounds.
Total gain with whole corn	281
Total gain with meal	242

The results of the two years' experiments are certainly favorable to feeding whole corn, for it seems to produce as much gain, pound for pound, as meal, and at least the cost of grinding is saved. Does it pay to even shell corn when that raised on the farm is fed?

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*The term grasses is used strictly in a botanical sense. The clovers are not true grasses.

The compounding of rations for the different classes of farm animals (pp. 102–122).—The nature of an efficient and economical ration and the sources from which it is to be obtained are described. German feeding standards are given in a table, with explanations. Dr. Jenkins's compilation of American analyses of feeding stuffs is reprinted from the report of the Connecticut Station for 1887. A table of digestion co-efficients from German sources is given and its use is explained.

Tests of varieties of potatoes, oats, barley, and peas (pp. 123–134).

The Station tested in the summer of 1886 a number of varieties of potatoes, oats and barley (see Maine Station Annual Report, 1886–87, pp. 104–107). The same varieties, with some additions were again grown in 1887 and 1888, also a large number of varieties of peas. The results of the year 1887 were reported in Bulletin No. 24 [of this Station], but as they have not appeared in the Annual Report of the Station they are reported here with the trials of 1888.

The report includes a brief record of tests of varieties in 1887 and 1888, with tabulated notes for 47 varieties of potatoes in the former year and 52 in the latter; for 22 varieties of oats grown in 1887 and 1888; for 7 varieties of barley grown in 1887 and 1888; and for 50 varieties of peas grown in 1887 and 53 in 1888.

Experiment in seed selection (p. 135).—Two quarts of the largest and heaviest kernels for each of four varieties of oats were selected and grown in comparison with seed of the same varieties of oats taken from common stock. The results stated in a table show no definite results in favor of the selected seed as to either amount of crop or weight of grain per measured bushel.

Report of Botanist and Entomologist, F. L. Harvey, M. S. (pp. 136–195).

Germination experiments (pp. 136–147).

The germinator used was a galvanized tray 8 inches deep, covered with a dome-shaped lid. On the inside of the tray, on two sides, and 1 inch from the top, were soldered waving shelves, in the grooves of which rods, to support pockets or folds of canton flannel cloth, were placed. Near the top of the tray, above the shelves, was a row of one-half-inch holes for admitting fresh air. Water to the depth of 2 inches was placed in the tray. The pockets were provided with two free ends of cloth which extended below into the water, carrying moisture to the seed by capillary attraction. The pockets were 3 inches deep and 2 inches from the water. The greater depth of water in the tray than is commonly used secured a more uniform temperature. Very small seeds were germinated in porous flower-pot saucers, set in water in the bottom of the tray, deep enough to keep them moist. To sterilize the trays and pockets they were scalded after each experiment. This apparatus was satisfactory.

In all the tests one hundred seeds were used. They were counted and weighed, and then put into the pockets without being soaked and spread so as not to touch each other. They were examined daily and those sprouted were removed, counted, and recorded. The experiments were continued two weeks, if any sound seeds remained that length of time unsprouted, and then the sound seeds left were counted.

A tabulated record is given of tests of 150 samples of the seeds of vegetables, clovers, grasses, and other forage plants. With some marked exceptions, the vegetable seeds showed a fair rate of vitality. In the case of the other kinds of seeds tested the range of vitality was as wide as was possible, being 100 in the cow-peas and incarnate or scarlet clover, and 0 in four of the grasses; that is to say, all of the former and none of the latter germinated.

As the conditions were very nearly the same in each case, it plainly shows the difference in seed. By comparing the grasses one will see that in the more common kinds, for instance timothy, the per cent germinated is high, 88 to 95, while in those rarely sown it is low. This is easily explained, as seed for which there is but a slight demand would remain on sale for a long time, so that the greater the demand the newer the seed. This is a good illustration of the difference between the new and old seed, as the per cent sprouted varies from 95 to 0, and from the more common to the less common kinds. The clovers show a high per cent of germination throughout, some of them sprouting 95 per cent in 24 hours from the time they were put in the germinator. * * * The conclusions we draw from these experiments put into rules to aid in purchasing seed, would be: See that seeds look new and fresh; notice whether they are plump or shriveled, and whether or not they are uniform in size. If some are large and some small, only the former will grow. Also see that they are free from foul seeds, as many troublesome weeds are introduced in this way. Buy of some reliable dealer, and continue to do so as long as the seeds are satisfactory. Buy seeds grown in our own State or from localities as far north. Farmers can easily test seeds by putting them between damp cloths, or sheets of blotting paper.

Experiments with forage plants (p. 147).—Sixty-six plats were sown last spring with grass seed and the seeds of other forage plants. * * * The Station has started a collection of seeds, and steps are also being taken to form a herbarium of grasses and other forage plants.

Potato scab (pp. 148, 149).—Brief notes on this disease, which is being investigated at the Station.

Apple scab or black spot (*Fusicladium dendriticum*) (pp. 149–151).—A brief account of the fungus and the disease caused by it, with suggestions as to remedies.

Injurious insects (pp. 151–195), (illustrated).—This contains compiled notes on the round-headed apple-tree borer (*Saperda candida*, Fab.), flat-headed apple-tree borer (*Chrysobothris femorata*, Fab.), oyster-shell bark-louse (*Mytilaspis pomorum*, Bouché), apple-tree tent caterpillar (*Clisiocampa americana*, Harris), forest tent caterpillar (*Clisiocampa sylvatica*, Harris), fall canker-worm (*Anisopteryx pometaria*, Harris), eye-spotted bud moth (*Tmetocera ocellana*, Schiff.), apple-tree aphis (*Aphis mali*, Fab.), codling moth (*Carpocapsa pomonella*, Linn.), apple maggot (*Trypeta pomonella*, Walsh), ash-gray pinion (*Lithophane antennata*, Walker), pear-tree slug (*Selandria cerasi*, Peck), plum curculio (*Conotrachelus nenuphar*, Herbst), cherry-tree plant-louse (*Myzus cerasi*, Fab.), imported currant worm (*Nematus ventricosus*, Klug), ivy scale insect (*Aspidiotus nerii*, Bouché), black swallow-tail butterfly (*Papilio asterias*, Cramer), eyed elator (*Alaus oculatus*, Linn.), hawthorn tingis (*Corythuca arcuata*), mourning-cloak butterfly (*Vanessa antiopa*, Linn.), meal-worm beetle (*Tenebrio molitor*).

There is also an account of experiments with insecticides, viz., Paris green, London purple, Hammond's slug shot, "peroxide of silicates" and "Doyen's Potato Bug Preventive" for destroying the potato beetle. Analyses of the materials are given. The last three owe their efficacy to small quantities of arsenic compounds, which are mixed with large amounts of plaster of Paris and other diluents.

The amounts of arsenic reported in the slug shot and peroxide of silicates were respectively 1.2 and 1.6 per cent, from one-thirtieth to one-fiftieth the amounts in Paris green, which is an aceto-arsenite of copper; or in London purple, which is mainly arsenite of lime. The "potato-bug preventive"—

> Is put up in small wooden boxes holding an ounce and a half of what appears to be merely a mixture of about four parts of starch and one part of Paris green. It is retailed at the modest sum of 50 cents per box. A similar mixture could be prepared from four parts of flour and one part of Paris green at a cost of less than 1 cent per box. Flour, which is cheaper than starch and just as good, has long been used as a carrier for Paris green.

The cost of Hammond's slug shot, peroxide of silicates, London purple, Paris green, and plaster is stated to show the relative expensiveness of the first two kinds, and the advantage of buying the arsenites and plaster separately and mixing them at home. Directions are given for sending specimens of insects, etc., to the Station.

ANALYTICAL AND EXPERIMENTAL METHODS, W. H. JORDAN, M. S. (pp. 195–203).

*Protein digestion.**—Experiments were made on artificial digestion of protein in different kinds of hay by pepsin and pancreas solutions. The materials used were the same as those used in the digestion experiments with sheep (see p. 53 of this digest).

> The methods employed in the artificial digestion experiments were essentially those finally proposed by Stutzer, viz., the digestion of the finely ground substance for 24 hours in an acid pepsin solution at 40° C., followed by digestion with a solution of pancreas for the same time at the same temperature.
>
> The variations in the methods were the use of scale pepsin instead of an extract from the inner membrane of a pig's stomach, the preparation of the pancreas solution in the way proposed by Dr. Chittenden, and in the case of some of the fodders the digestion with pancreas for only 12 hours.

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* Printed in advance, nearly as given in the Report, in Agricultural Science, November, 1888.

Digestibility of protein by pepsin-pancreas digestion.

Station No.	Species.	Year.	In water-free substance.			Total nitrogenous material digested.	Albuminoids digested.
			Total nitrogen.	Albuminoid nitrogen.	Undigested by pepsin-pancreas digestion.		
			Per cent.	*Per cent.*		*Per cent.*	*Per cent.*
XXIV.	Alsike clover	1886	1.81	....	.87	52.0	....
XLI.	... do	1887	2.32	2.02	.457	80.3	77.4
XLII.	White clover	1887	2.76	2.32	.502	81.8	78.4
XLIII.	Blue joint	1887	1.61	1.42	.525	67.4	63.0
XXVII.	Oat straw	1886	.63	....	.344	45.6	....
XL.	Orchard grass	1887	1.35	1.29	.393	70.9	69.6
L.	Redtop	1887	1.55	....	.557	64.1	....
XXIII.	Timothy	1886	1.07	....	.464	56.5	....
XLIV.	....do	1887	1.31	1.17	.338	74.2	71.1
LI.	....do	1867	1.25	....	.465	62.8	....
XLV.	Wild oat grass	1887	1.20	1.08	.414	65.5	61.7
XXXIX.	Witch grass	1887	1.52	1.39	.325	78.7	76.6
XLVI.	Buttercup	1887	1.62	1.53	.391	75.9	74.5
XLVII.	White-weed	1887	1.49	1.40	.398	73.3	71.5

Comparison of methods for the determination of the digestibility of protein.—The usual method of determining the digestibility of feeding stuffs by feeding experiments with animals consists in taking the quantity of each kind of nutrient, as protein, fat, or non-nitrogenous extract found by analysis in the food eaten, subtracting the amount found by similar analysis of the solid excrement, and assuming that the difference represents the amounts actually digested. This would be correct if the amounts of intestinal excretion represented the undigested residue and there were no other sources of error. Such, however, is not the case. The excreted material contains metabolic products from the bile and other digestive fluids, the mucus, epithelium of the alimentary canal, etc., which have been digested and assimilated from previously ingested food, and having served their purpose are given off with the undigested portion of the food whose digestibility is being tested. To make the digestion tests acurate, then, it is essential to know the amount of these metabolic products. The attempt has been frequently made to test the digestibility by the arbitrary method of artificial digestion with pepsin-pancreas solution, etc., as in the experiments here reported. The co-efficients of digestibility by the natural and artificial digestion differ widely, as may be seen in the table beyond, in which results by different methods are compared.

The most promising direction in which to look for an explanation of widely different results for protein by the two methods seems to be in a study of the nitrogen compounds of the fæces.

If by any means it is possible to separate the actual undigested residue of protein from the other nitrogen compounds of the solid excrement, we shall have a standard by which to judge artificial methods of digestion, as well as a means of correcting the co-efficient of digestibility for protein, as usually calculated, if such correction is necessary.

Three methods have been tried for the separation of the biliary and other waste products from the real undigested food residue, viz., (1) successive treatment of the fæces with ether, alcohol, and hot water; (2) the same followed by cold lime-water; and (3) digestion with a pepsin solution. The treatment with ether was the same as for a fat extraction, and with the alcohol and water, 50 c. c. of each were used for each gram of substance, the solvents being added cold, brought quickly to the boiling point, and kept at that temperature for about 10 minutes, filtered at once, and the residue washed with the same liquid used for extraction. The treatment with lime-water consisted in letting 1 gram of the substance stand in 50 c. c. of a saturated solution for 6 hours in the cold. The pepsin solution was the same as that used in digestion of fodders, the time of treatment being 24 hours. The nitrogen was determined in the residues after extraction, and not in solution.

Determinations by two persons, one using 2 grams of substance and the other 1 gram, gave practically the same results.

The results of these different methods of treatment of the fæces are stated in tabular form.

In the following table are given the co-efficients of digestibility as estimated by subtracting from the total nitrogen of the food the undigested nitrogen, assuming for the amount of the latter: A, the total nitrogen of the fæces; B, the total fæcal nitrogen less the amount which was extracted by ether, alcohol, hot water, and lime-water, and was reckoned as belonging to the metabolic products; C, the total fæcal nitrogen less the metabolic nitrogen as estimated by extracting with pepsin solution; D, the nitrogen left after digesting the food by pepsin and pancreas solutions.

Estimates of digestibility of protein by different methods.

Station No.	Species.	A.	B.		C.		D.	
		Results as obtained from feeding experiments with animals.					Results as obtained by artificial digestion of feeding stuffs by pepsin and pancreas solutions.	
		By ordinary method.	Corrected to make allowance for metabolic products, estimated by:					
			Extraction of fæces with ether, alcohol, hot water, and cold lime-water.		Digestion of fæces by pepsin solution.			
		Protein estimated to be digested.	Protein estimated to be digested.	Excess over ordinary method.	Protein estimated to be digested.	Excess over ordinary method.	Protein estimated to be digested.	Excess over ordinary method.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
XXIV	Alsike clover	59.1	65.2	6.2	69.6	10.5	52	—6.6
XXIV	....do	58.1	64.7	6.6	68.9	10.8		
XLI	do	64	72.1	8.1	77.9	13.9	80.3	16.3
XLII	White clover	73.3	81.5	8.2	84.5	11.2	81.8	8.5
XLIII	Blue joint	56.4	69	12.6	73.9	17.5	67.3	10.9
XL	Orchard grass	58.5	73.3	14.8	75.7	17.2	70.8	12.3
XXVII	Oat straw	—15.2	13.4	28.6	19	34.2	45.6	....
XXVII	....do	— 2.5	27.7	30.2	38.4	40.9		
XXVII XXX	Oat straw and raw potatoes.	25.9	45.4	19.5	59.5	33.6	78.5	51
XXVII XXX	....do	29	52.7	23.7	68.1	39.1		
L	Redtop	60.4	68.4	8	72.6	12 2	64.1	3.7
XXIII	Timothy	45.6	60.2	14.6	65.8	20.2	56.6	11.4
XXIII	....do	44.9	57.9	13	61.6	16.7		
XLIV	....do	60.4	69.8	9.4	74.8	14.4	74.2	13.8
LI	....do	44.5	56.7	12.2	64	19.5	63	18.5
XLV	Wild oat grass	48.5	63.4	14.9	68	19.5	65.4	16.9
XXXIX	Witch grass	64.2	73.9	9.7	80.5	16.3	78.7	14.5
XLVI	Buttercup	57.8	67.5	9.7	72.6	14.8	75.8	18
XLVII	White-weed	58.4	65.7	8.3	72.8	14.4	73.3	14.9

It appears that method A gives uniformly much lower results than either of the other three methods, method C giving the highest. The average co-efficients obtained by the four methods in 15 of the 19 trials, excluding the experiments where oat straw alone and oat straw with potatoes were fed, are as follows:

Method A, 56.9 per cent.
B, 67.3—10.4 above A.
C, 72.2—15.3 above A.
D, 67.5—10.6 above A.

The increase of co-efficients of digestibility due to the corrections applied range in the 15 experiments from 6 per cent to 14.9 per cent with method B, and from 10.5 per cent to 20.2 per cent with method C.

In those experiments where the daily ration was only 350 grams of oat straw, or 350 grams of oat straw and 1,000 grams of raw potatoes, the amount of nitrogen extracted as presumable metabolic products is relatively much larger, and in these instances the co-efficients by method B are from 19.5 per cent to 30.2 per cent, and by method C from 33.6 per cent to 40.9 per cent larger than by method A. The large differences in the results by the three methods in these two experiments are due to the fact that in one case an abnormally small amount was fed of a food poor in nitrogenous material, and that in the other the amount of material added to the oat straw contained a relatively large quantity of digestible substance as compared to the additional protein consumed.

The metabolic nitrogen seems to be proportioned to the total food rather than to the nitrogen in the food. A table is given showing that the metabolic nitrogen, as estimated by method B, ranged from 0.19 to 0.50 gram for each 100 grams of organic nitrogen digested, and from 0.96 to 4.80 grams for each 100 grams of protein fed. That is to say, the first range of variation is less than the second, or in other words, the metabolic nitrogen bears a more nearly fixed relation to the material digested than to the protein fed. In entire accordance with this—

The error involved in method A is, in general, inversely to the amount of nitrogen in the food. The corrections of methods B and C, then, affect the co-efficients for oat straw and timothy much more than that for clover hay. * * *

The value of the foregoing observations as an aid in solving the problem of protein digestion must be decided according to the answer given to the following question: Do the solvents used in methods B and C extract from the fæces any of the undigested protein? If not, then there seems to be good reason for applying some method of correction to the co-efficients of digestibility of protein as usually determined. If nitrogenous waste products are present in the fæces to the extent these methods indicate, the error they cause is too large to be ignored.

Let us first consider method B. The solvents used are ether, hot alcohol, hot water, and cold lime-water. It seems to be generally acknowledged that the ether and alcohol remove only biliary products. This assumption may safely be regarded as correct, unless the fæces contain amides, certain acid amides at least being soluble in both these liquids. If amides or peptones are present then the extraction with hot water is also not allowable; otherwise it would seem to be for it is not probable that treatment of the fæces for 10 minutes with hot water would dissolve any albuminoids that had withstood the long-continued action of the digestive fluids. In fact Dr. Armsby's work on the separation of albuminoids from amide nitrogen in hay shows that treatment with hot water extracted no more nitrogen than Stutzer's method, where a precipitant is used to bring down any albuminoids that might be in the water solution. It seems hardly probable that the fæces contain peptones or amides. These are compounds soluble in water, and are those into which the albuminoids of the food are transformed in order that they may be resorbed. It seems as probable that these substances should be wholly resorbed as that sugar should be, which is either in the food or is formed from the starch of the food, and, as can be seen later, the fæces examined in these experiments were found to contain no sugar. In future work, however, tests will be made for peptones and amides.

An examination of the figures given shows that the action of cold lime-water for 6 hours removed considerable nitrogen not taken out by the other three solvents. Did any of this nitrogen come from the albuminoids of the fæces ? The results of an experiment with two kinds of hay indicate a negative answer to this question. Hays XLII and LI were submitted to an ordinary pepsin digestion for 24 hours, and also to the usual pepsin-pancreas digestion, after which they were allowed to stand for different lengths of time in a cold saturated solution of calcium hydrate. Below are the figures showing the nitrogen in the hay before and after standing in the solution:

		Nitrogen in residue.		Nitrogen in residue after additional treatment with cold lime-water.				
		After pancreas digestion.	After pepsin-pancreas digestion.	1 hour.	2 hours.	4 hours.	6 hours.	36 hours.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
XLII	White clover hay		.49				.46	
LI	Timothy hay	.41	.45	.43	.42	.43	.40	.39

As has been observed, the digestion with a pepsin solution (method C) extracts more fæcal nitrogen than method B. Does method C extract too much ? It now seems to the writer that there is some reason for thinking that it does. By method B the nitrogen extracted is that which is readily and immediately dissolved, while the pepsin solution continues to remove an increasing quantity up to 24 hours' digestion, and perhaps further. This matter was made the subject of but one experiment. The fæces from LI were treated with pepsin solution for 6, 12, 18, and 24 hours, the nitrogen in the water-free residues being 1.19, 1.08, 1.04, and 0.99 per cent, respectively.

Again, the co-efficients of digestibility by method C average considerably higher than by methods B and D (pepsin-pancreas digestion), while the two latter agree closely with each other.

Nearly twenty digestion experiments are now being planned for the next years' work at this Station, and an effort will be made to so increase the data bearing on the main points here presented that more definite conclusions can be reached.

Summary.—(1) These investigations add new evidence that the digestion co efficients for protein obtained by the ordinary method are much too small, and that the error is greater as the total food digested is larger and the protein of the food smaller.

(2) At the very outset of investigations of digestibility by the ordinary way, there is the error involved in taking the product of the nitrogen by the factor 6.25 as a measure of the protein in either the food consumed or the actually undigested residue. But leaving this out of account, the chief error is in the fact that the fæcal nitrogen includes with that of the undigested food, a considerable amount from metabolic products, ptyalin, pepsin, bile and other digestive juices, mucus, intestinal epithelium, etc.

(3) In the experiments here reported the digestion co-efficients of 15 specimens of hay from clovers, grasses, buttercup, and white-weed, as determined by the ordinary method (A), averaged 56.9 per cent.

Allowing for metabolic nitrogen as estimated by extracting the fæces with ether, alcohol, hot water, and cold lime water (B), the average was 67.3 per cent, implying an error of 10.4 per cent, or nearly one-sixth of the whole protein digested. The range of seeming error was from 6.0 to 14.9 per cent. In four experiments with oat straw fed alone and with potatoes, the co-efficient of digestibility of the protein by the ordinary method averaged 9.8 per cent. Allowing for metabolic nitrogen as before, it averaged 34.8 per cent. The apparent error ranged from 19.5 to 30.2 and averaged 25.5 per cent.

(4) The consideration of the probable composition of the fæcal metabolic products led to the inference that they would probably be dissolved by the treatment with ether, alcohol, hot water, and cold lime-water successively. In like manner it seemed probable *a priori* that neither the ether nor the alcohol nor the hot water would remove undigested nitrogenous materials unless it be (unabsorbed) amides or peptones, the presence of which in the fæces was possible. Experiments in which residues from artificial pepsin and pancreas digestion of hay were treated with lime-water gave no indication of the solution of any considerable amount of undigested nitrogen by that re-agent. The inference is that the fæcal nitrogen remaining after the treatment with ether, alcohol, hot water, and cold lime-water represented pretty nearly the undigested nitrogen of the food.

(5) Artificial digestion (method D) of the 15 specimens of hay with pepsin and pancreas solutions, digestion co-efficients which averaged 67.5 per cent. This accords very closely with the average by method B, 67.3 per cent. This tends to confirm the correctness of method B.

(6) By treating the fæces with pepsin solution (method C) more nitrogen was dissolved out than by method B. It would seem that some of the undigested protein, *i. e.* that not dissolved by the digestive juices and absorbed in the passage through the alimentary canal, was dissolved by the pepsin solution. One series of trials was made in which fæces from hay were treated with pepsin solution for different lengths of time, from 6 to 24 hours. The amount of nitrogen dissolved increased uniformly with the time of digestion. This tends to support the inference that by method C undigested nitrogen is dissolved.

In brief, these experiments confirm the incorrectness of the ordinary method for determining the digestibility of protein by the ordinary method of subtracting the total fæcal nitrogen from the total nitrogen consumed. They also accord with the common assumption that the error is largely, if not chiefly, due to metabolic products, and that it is the larger the less the nitrogen in the food and the more the organic matter digested. They imply that more nearly correct results can be obtained by approximate determination of the metabolic nitrogen (extraction with ether, alcohol, hot water, and cold lime-water), and making a correction therefor; or by artificial digestion with pepsin and pancreas solutions.

REPORT OF CHEMIST, J. M. BARTLETT, M. S. (pp. 204–209).

Fertilizers.—In the analyses published in the report the official methods adopted by the Association of Official Agricultural Chemists (see Bulletin No. 16, U. S. Department of Agriculture) were quite closely followed. The most important variations are described, in substance as follows:

Soluble phosphoric acid.—In this determination the substance is brought directly upon a filter and leached with 300 to 350 c. c. water into a 400 c. c. flask, care being taken to add the water in small portions at first, and allow each portion to run through before adding a new one. After the leaching is completed the solution is made up to the mark and 100 c. c. taken for analysis. This seems to us the simplest and best method yet recommended, as we get no higher results by following the official directions. Washing by decantation from a beaker is especially objectionable with phosphates that revert rapidly as quite a portion of the phosphoric acid is precipitated in the beaker and remains on the filter.

In many instances only 15 to 20 minutes time has been allowed for the precipitation of phosphoric acid and ammonium molybdate, and it has always been found to be completely precipitated.

Potash.—The same method as employed heretofore and described in Maine Experiment Station report for 1886–87, has been used, as it has required less time than the Gladding method and gives accurate results.

Nitrogen.—The determination in presence of nitrates was as follows:

When nitrates were present a modification of the Kjeldahl Jodlbauer method, which was worked up and tested at this Station during the summer of 1887 but not published heretofore, has been used. Practically the same method has been suggested and tested by other chemists since that time with good results.

The method is as follows: 1 gram finely powdered substance is introduced into a dry digestion flask, 30 c. c. concentrated sulphuric acid containing 1¼ grams phenol added, shaken until thoroughly mixed and allowed to stand 10 minutes at ordinary temperature. One-half to 2 grams powdered zinc is then added, the flask placed over a very low flame and heated cautiously for 15 minutes, when about .7 grams mercury is added and the flame increased sufficiently to boil the acid. The remainder of the process does not differ from the regular Kjeldahl method.

This method has proved very reliable when properly worked. The only precautions necessary to secure good results are, to mix the substance with the acid and phenol thoroughly before adding zinc or heating, and to have the flame very low on beginning to heat.

A table gives results of comparative tests, which agree closely with each other and with the theoretical figures.

Milk.—Methods for solids, fat, nitrogen, and ash are given.

Sugar and starch in coarse fodders.—The methods used for the digestion experiments previously described are here cited.

Sugars.—Five grams of the finely powdered substance are placed in a beaker, 100 c. c. water at 40° C. added and allowed to stand for one-half hour, with frequent shaking. The extract is then filtered through paper into a 250 c. c. flask, the substance brought upon the filter and leached with water at ordinary temperature till the solution is made up to 250 c. c. Twenty-five c. c. of this solution are taken for determination of glucose and another portion of 25 c. c. is heated, after adding a few drops of HCl, in a covered beaker on the steam bath, for one-half hour, then neutralized with

KHO and total sugar* determined. Allihn's method and tables † were used in all cases for all sugar determinations, except that instead of reducing the copper oxide to copper it was ignited and weighed as CuO and the Cu calculated. Several comparisons showed this method to be accurate.

Determination.	Cu reduced.	Cu calculated from CuO.
	Milligrams.	*Milligrams.*
I	.0715	.0718
II	.378	.379
III	.380	.375

Starch.—The 5 grams that have been leached for sugars are washed into a flask with 150 c. c. water, the flask attached to a condenser to prevent the escape of steam and the contents boiled for one-half hour. Then 50 c. c. of a 2 per cent solution of HCl are added and the boiling continued for one-half hour more, the solution filtered through linen into a beaker, and the residue thoroughly washed with hot water. (The washing is much facilitated by wringing the water completely out each time before adding a new portion.) The beaker is then placed on a steam bath, the solution evaporated to nearly 200 c. c. and 15 c. c. HCl (sp. gr. 1.12) added and the heating continued for 3 hours. The solution is then filtered if necessary, transferred to a 250 c. c. flask, made slightly alkaline with KHO, filled to the mark, and filtered through dry filter. Twenty-five c. c. are taken for each determination.

The above method was employed for the determination of starch in some coarse fodders and excrements where it was thought desirable to use a method that was compatible with our present one for determination of crude fiber. Most of the methods published heretofore subject the fodder to the direct action of the acid for the time required to convert the starch to sugar.

Such treatment will give a much larger percentage of starch than is found in the acid solution from a crude fiber determination, and will also reduce the total amount of fiber in about the same proportion. A few comparative tests were made with the method recently published by Mr. E. F. Ladd,‡ in which the fodder is treated with 150 c. c. water containing 4 to 5 c. c. concentrated HCl for 12 hours at 100° C.

A sample of timothy treated by this method gave about 7 per cent more starch than the method described above, and to ascertain whether the cellulose was very much acted on, a crude fiber determination was made, treating the fodder with 200 c. c. water containing 5 c. c. concentrated HCl at 100° C. for 8 hours, then one-half hour with alkali as by the regular crude fiber determination, and the result was about 5 per cent less fiber than when treated one-half hour with 1¼ per cent sulphuric acid in the usual manner. As a further test, 5 grams of crude fiber were treated by Mr. Ladd's method and the extract tested with Fehling solution. The amount of copper oxide precipitated was equivalent to 6.4 per cent of starch.

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* May contain the inversion products, not only of sucrose, but also of dextrin, galactan, etc. (see Maxwell, Am. Chem. Jour., Vol. XII, No. 4, third page of article).

† Fresenius's Quan. Chem. Analysis, 6th ed., pp. 595–597.

‡ New York Agricultural Experiment Station, Sixth Annual Report, p. 462.

By boiling a fodder one-half hour with a one-half per cent HCl solution as much material that reduces Fehling solution is rendered soluble as when a 1.25 per cent sulphuric acid is used. The following fodders were treated with both acids:

	Equal to starch.	
	One-half per cent HCl.	One and one-quarter per cent H_2SO_4
Sample A, corn fodder	13.7	12.7
Sample B, redtop	15.16	16.0
Sample C, timothy	13.80	13.5
Sample D, alsike clover	9.31	9.17

HCl was employed to bring the starch into solution for the reason that it is considered more favorable to the conversion of starch to sugar than sulphuric acid, and a mixture of acids during the latter part of the process was not desirable.

The strength required was determined by making a number of crude fiber determinations, substituting HCl solutions of varying strengths for the 1.25 sulphuric acid, until one was found that gave practically the same crude-fiber.

The treatment with acid removes nearly all the matter that reduces Fehling solution, which is extracted in a crude fiber determination, but a small amount being found in the alkali solution. Several alkali solutions that were examined contained less than 2 per cent, and as high a percentage of starch was obtained by boiling the substance one-half hour with water previous to treating it with acid as when both alkali and acid solutions were used.

REPORT OF CHEMIST, L. H. MERRILL, B. S. (pp. 210–213).

Fodder analysis.—"The methods used during the year were those recommended by the American Association of Official Agricultural Chemists," except for ash, ether extract, and crude fiber, for which the minor variations were made and are explained.

Artificial digestion.—The pepsin and pancreas solutions used in the experiments previously described were prepared in the manner described in the report of the Station for 1886–87, p. 128, as follows:

The pepsin solution used consisted of 5 grams of scale pepsin dissolved in one liter of 0.2 hydrochloric acid. Two grams of the substance were digested for 24 hours (12 hours on each of two consecutive days) in 250 c. c. of this solution, hydrochloric acid (0.1 per cent) being added at regular intervals until the solution contained 1 per cent. The undigested residue was then washed thoroughly and submitted to digestion in a pancreas solution, made after a method suggested by Dr. R. H. Chittenden, of Yale College (see Connecticut State Experiment Station Report for 1885, p. 45).

The sweet breads (pancreas) of neat cattle were finely cut and allowed to remain in a large quantity of alcohol for a week or more. After the alcohol was strained off the residue was extracted with ether, dried, ground, and bottled. To prepare the solution 25 grams of the dry pancreas, together with 2.5 grams of salicylic acid and 250 c. c. of water were heated for 12 hours at 40° C. The solution was then filtered, and the residue washed until the filtrate and washings amounted to one liter. Two hundred c. c. of this solution were used in each experiment, with 0.6 gram of sodium carbonate and a few drops of a solution of 20 grams thymol in 100 c. c. alcohol. The digestion was continued for the same length of time as with the pepsin solution.

[In 1888] the pepsin solution was allowed to act 24 hours (two days of 12 hours each). The time for the pancreas digestion, however, was shortened to 12 hours. It is probable that even a shorter time would suffice (Stutzer, *Zeit. Phys. Chemie*, XI, pp. 207–238), but no experiments were made to test this point.

To ascertain the effect of reducing the time of the pepsin digestion, samples of corn meal and white clover were treated in the usual manner, while in a duplicate set the action of the pepsin was limited to 12 hours. The nitrogen found in the undigested residues is shown below:

	Undigested.	
	24 hours pepsin, 12 hours pancreas.	12 hours pepsin, 12 hours pancreas.
	Per cent.	*Per cent.*
Corn meal, XX,	.26	.42
White clover, XIII	.49	.54

A sheep excrement, after 6 hours with pepsin alone, gave nitrogen 1.12 per cent; after 12 hours, 1.02; 18 hours, .98; 24 hours, .93.

It would appear from these figures that the full effect of the pepsin is not obtained in 12 hours—at least in the case of the materials named. In this work much depends upon the complete separation of the digestive fluids from the residue, and the careful washing of the latter. As a rule, the filtrations were effected with extreme difficulty, and a few anomalous results were manifestly due to the fact that a part of the digested material remained upon the filter.

The best results were obtained by the use of the "Best German" filter paper. Soft filters, 13 centimetres in diameter, were selected and pleated. After the final washing no attempt was made to separate the residue from the paper. When dry the tops of the filters were cut away, and the nitrogen determined in the whole by the Kjeldahl method.

Loss of nitrogen from nitrogenous superphosphates.—Andouard* calls attention to the loss of nitrogen which many superphosphates suffer through the decomposition of nitrates. This decomposition he believes to be due to the presence of free phosphoric, sulphuric, or fluorhydric acids.

The statement has also been made that sodium nitrate undergoes decomposition in the presence of free sulphuric acid together with large quantities of iron sulphate and organic matters.†

Six nitrogenous phosphates were prepared in the Station laboratory, by mixing 60 or 100 grams sodium nitrate with 500 grams of either dissolved bone-black or dissolved South Carolina rock. To each of four of the mixtures, those having the 60 grams of nitrate, 100 grams of dried blood were added. In two of the same cases, one with bone-black and one with South Carolina rock, 60 grams of ferrous sulphate were added.

From time to time the nitric acid and total nitrogen were determined in these samples. In order that the results might be compared the moisture was also determined and all the results reduced to a water-free basis.

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*Comptes rendus, Tome CIV, Nr. 9, S. 583–585; Bied. Centralblatt, Mai, 1887, S. 304–305.

†Chemiker Zeitung, 1887, Nr. 36; Bied. Centralblatt, Mai, 1887, S. 305.

The first determinations of total nitrogen were made by the absolute method, the others by the modified Kjeldahl method. The results are given below:

	Aug., 1887.		Oct., 1887.		Dec., 1887.		July, 1888.		Dec., 1888.
	Total nitrogen.	N. in nitrate.	Total nitrogen.	N. in nitrate.	Total nitrogen.	N. in nitrate.	Total nitrogen.	N. in nitrate.	Total nitrogen.
1	3.53	3.18	3.42	3.09	3.18	3.24	3.13	3.07	3.07
2	3.60	1.79	3.50	1.70	3.51	1.72	3.64	1.71	3.50
3	3.38	1.62	3.46	1.65	3.29	....	3.26	1.54	3.12
4	3.06	....	....	3.05	3.25	....	2.94	2.88	2.89
5	3.43	1.66	4.45	1.70	3.14	1.64	3.31	1.68	3.26
6	3.28	1.47	....	1.48	2.91	1.49	2.97	1.48	3.06

The amount of moisture present varied greatly from time to time, and the apparent fluctuations in the amount of nitrogen were undoubtedly due in part to errors in reducing the results to a water-free basis.

Four months before the last determinations were made the samples were wet almost to a paste. Although the conditions were made as favorable as possible to the changes indicated by Andouard, yet the results obtained seem to show that the loss, if any, was trifling.

Method for phosphoric acid.—Isbert and Stutzer (*Zeit. Anal. Chemie.* 26, 583) propose a simplification of the ordinary method of determining phosphoric acid. The abridgment is based upon the constant relation which is said to exist between the ammonia and the phosphoric acid in the ammonium phospho-molybdate precipitate. * * *

In order to test the applicability of this method to general laboratory use a number of trials were recently made at this Station. The results obtained were not satisfactory. Great difficulty was experienced in washing from the filter the last traces of ammonium nitrate contained in the molybdate solution. * * *

As regards the use of cold water in washing the ammonium phospho-molybdate precipitate, it was found that in a few cases slightly lower results were obtained than when ammonium nitrate was employed. The differences were so slight, however, that it was decided to make this substitution in fertilizer analyses of the coming year.

MARYLAND.

Maryland Agricultural Experiment Station.

Department of Maryland Agricultural College.

Location, Agricultural College. Director, Henry E. Alvord, C. E.

FIRST ANNUAL REPORT, 1888.

REPORT OF DIRECTOR (pp. 49–57).

The charter for the Maryland Agricultural College and "Model Farm," granted in 1856, included the following important section:

"SEC. 6. It shall be the duty of the said Board of Trustees to order and direct to be made and instituted on said model farm, annually, a series of experiments upon the cultivation of cereal and other plants adapted to the latitude and climate of the State of Maryland; and cause to be carefully noted upon the records of said institution the character of said experiments, the kind of soil upon which they were undertaken, the system of cultivation adopted, the state of the atmosphere, and all other particulars which may be necessary to a fair and complete understanding of the result of said experiments."

Under the law quoted, field experiments were conducted on the Maryland College farm during the years 1858 and 1859, even before the institution was ready for students.

The Station was organized April 1, 1888. Between 40 and 50 acres of the college farm were chosen for experimental purposes.

A great diversity of soil is included for such an area in compact form. There are clays more or less stiff and tenacious, and varying in color from deep red to bluish gray and almost white; loams of all grades, with more or less gravel mixtures, and some acres of very light, sandy soil. Nearly all the land is worn, and greatly reduced in productiveness by continued cropping. It will, therefore, respond quickly to applications of fertilizing materials of any kind, and is otherwise particularly well suited for experimental work. Much fencing had to be done, and a good deal of draining is still necessary to bring the land into satisfactory condition.

A two-story brick building, with an annex, located on the above-mentioned piece of land, was assigned to the Station.

Although nearly a hundred years old and much out of repair, it remained a substantial structure, the main building being 45 by 35 feet on the ground, and the annex 43 by 18 feet. The main building has had a third story added, and all has been remodeled and thoroughly repaired at an expense of about three thousand dollars, so that very suitable and satisfactory quarters for the Station have now been provided.

In this building are two offices, chemical laboratory, library, museum, several living rooms for members of the Station staff, workshop, seed-room, store-rooms, etc.

The buildings are heated by steam, supplied with hot and cold water under pressure, and the principal rooms lighted by gas from an automatic machine provided for the laboratory. Excepting the museum and one smaller room, the buildings are well finished, furnished, and equipped for their special uses.

Library.—The library has already been provided with several hundred volumes, including American, English, German, and French works of reference. Numerous scientific periodicals are kept on file, and nearly all of the leading agricultural journals of this country. The Station also has the use of the large collection of agricultural books and pamphlets owned by the director.

Exhibitions.—During the autumn, displays were made by the Station, in the form of object lessons illustrative of its work, at the annual agricultural exhibitions of the counties of Harford and Frederick, and the State fair at Hagerstown. Members of the Station staff, assisted by students of the senior class of the college, were in attendance to explain the exhibits, distribute bulletins, and give information regarding the Station and its purpose. The exhibits thus made received much attention and commendation.

Besides the equipment of the chemical laboratory, the general appliances include meteorological instruments, with soil thermometers, surveying instruments, seed testers, balances and scales for all grades of weighing, and farming tools and implements sufficient for present purposes. The Station owns a good pair of mules, two Ayrshire heifers, and a few Yorkshire pigs. Animals owned by the college and others (private property) are also available for experiment.

The Station staff includes the director and five assistants, besides from four to six laborers and students of the college temporarily employed.

In connection with the fencing of the experimental fields, tests of fencing materials, methods of preservation of fence posts, etc., are being made.

Field experiments.—Uniformity of soil.—"To secure a proper basis for future work several acres were laid out in plats and cultivated in even-growing plants (field corn and soja beans), without manures, thus testing the uniformity and natural productiveness of the soil." An unsuccessful attempt was made to compare the value of an acre of oats while in bloom and cured as hay with a like crop harvested as grain and straw. Trials were made with several varieties of cow-peas and sorghum. "A silo containing three compartments was built at the college cattle-sheds during the summer, its total capacity being about 90 tons. The pits were filled, for experimental purposes, with material to make ensilage of several different kinds." Accounts of this work are given in the report of the agriculturist.

"Upon 4 acres, divided into eight plats of one square half acre each, different methods were tried of growing corn and sorghum for fodder. This experiment and its results form the subject of Bulletin No. 3, issued by the Station December, 1888." Different methods of cutting and planting seed potatoes were also tested. The details of the experiment were published in Bulletin No. 2 of this Station, September, 1888.

Experimental orchard.—The fruit interests of Maryland are so great (and still increasing) as to demand a fair share of the attention of this Station. As a preparation for variety tests and subsequent special fruit investigations, a large orchard has been planted during the past autumn.

Bulletins.—Three bulletins have been published, as follows:

No. 1, June—History, Organization, and Work of the Station.

No. 2, September—Cutting Seed Potatoes for Planting.

No. 3, December—Fodder Cane and Fodder Corn, with Appendix.

Editions of six to ten thousand of these have been distributed to individuals desiring them.

The correspondence of the Station is large and increasing. Meetings of farmers in eight counties were attended by Station officers.

REPORT OF HORTICULTURIST, W. H. BISHOP, B. S. (pp. 59–65).—This is for the most part a résumé of the conclusions reached by the author from "a critical examination of the records of the numerous experiments designed to ascertain the proper amount of seed potato to plant," in connection with the experiment reported in Bulletin No. 2 of this Station. In this experiment the results of planting whole potatoes, quarters, and 2-eye and 1-eye pieces were compared for forty varieties. In this case, as in numerous other similar experiments, the yield was largest with the whole potatoes, and decreased in proportion to the decrease in quantity of seed potatoes planted. The following table gives a summary of the experiment:

Average result from forty varieties of potatoes.

[Product per acre.—Five different methods of seeding.]

Row.	Form of seed potato planted.	Total yield.	Merchantable.	Unmerchantable.
		Bushels.	*Bushels.*	*Bushels.*
A	A large whole potato	268.95	172.12	96.83
B	A whole potato, size of egg	174.36	106.70	67.66
C	Usual cutting, one piece	134.24	82.75	51.48
D	A single eye, on good-sized piece	90.53	58.87	31.65
E	A single eye, on very small piece	57.98	33.10	24.87

The general conclusions stated in this report are in brief as follows:

(1) A large majority of the experimenters have arrived at the conclusion that *the larger the quantity of seed planted the greater the corresponding crop.* * * *

(2) It is never profitable in field culture, to plant a single eye bearing less than its proportion of the substance of the whole tuber. With garden culture and an exceedingly limited quantity of seed, as in the case of a rare or high-priced novelty, methods of propagation that have no place in field culture may be resorted to with profit. * * * For the farmer, the cases are very rare when the planting of a single eye in a hill is desirable. * * *

(3) There is no evidence to prove that there is any advantage in planting pieces of large potatoes instead of pieces of small ones, or even whole small tubers of equal weight with the former. * * *

(4) There is very little difference in the productiveness of the different parts of the tuber, the advantage, if there is any, being in favor of the tip or "seed end," as from it we get the earliest and most vigorous plants. * * *

(5) There is very little to show that a whole tuber may be profitably planted with all eyes except one or two cut out. The theory that the larger amount of food thus available for the young plant would produce a larger crop is not supported by experience. * * *

(6) Probably there is no loss of crop if the pieces are planted within a week or ten days after cutting, and in case the soil is wet after planting the dried pieces may be better able to withstand a tendency to rot before sprouting.

(7) The selection of the tuber for planting is worthy of more attention than is ordinarily given it, for there is some evidence that potatoes taken from the most productive hills produce more than those from less productive ones. There seems to be the strongest theoretical probability that continued selection in this direction would result in marked increase of yield.

The following list of references to seed-potato experiments is given:

U. S. Department of Agriculture Reports for 1847, 1867, 1869, 1874, and 1875.

Ohio Agricultural Experiment Station Reports for 1882, 1883, 1884, 1885, and 1886.

New York Agricultural Experiment Station Reports for 1883, 1884, 1885, 1886, and 1887.

Massachusetts Agricultural Experiment Station Reports for 1884, 1886, and 1887.

Cornell University Experiment Station Reports for 1883, 1885, 1879, and 1880.

Wisconsin Experiment Station Report for 1883.

Vermont Experiment Station Report for 1888.

Pennsylvania Agricultural College Reports, 1886 and 1887.

Missouri State Board of Agriculture Reports, 1871, 1872, and 1873.

Wisconsin Agricultural Experiment Station Bulletin No. 13, February, 1888.

Minnesota Agricultural Experiment Station Bulletin No. 1, January, 1888.

Kentucky Agricultural Experiment Station Bulletin No. 9, March, 1887, and No. 16, December, 1888.

Colorado Agricultural Experiment Station Bulletin No. 4, February, 1888.

Maryland Agricultural Experiment Station Bulletin No. 2, September, 1888.

Michigan Agricultural College Bulletins Nos. 13 (1885) and 34 (March, 1888).

Missouri Agricultural College Bulletin No. 12, October, 1884.

New Hampshire Agriculture, 1880.

Agriculture of Massachusetts, 1886.

Journal of the Royal Agricultural Society, England, 1867.

Journal d'Agriculture Pratique, 1870.

Country Gentleman, January 18, 1887.

New England Homestead, November 23, 1888.

REPORT OF CHEMIST, H. J. PATTERSON, B. S. (pp. 66–69).—This contains an account of the equipment of the chemical laboratory of the Station and tabulated records of analyses of 8 brands of commercial fertilizers and 19 samples of fodder materials, including 7 of fodder corn, 2 of sorghum, 2 of oats used for hay, 1 of Johnson grass, 4 of soja beans, and 3 of cow-peas.

REPORT OF AGRICULTURIST, A. I. HAYWARD, B. S. (pp. 70–75).—This includes brief reports on (1) the yield of corn, without manure, on 6 half-acre plats in 1888—the first of a series of experiments in crop rotation; (2) the yield of soja beans, without manure, on 3$\frac{3}{7}$ acres, divided into 27 plats—an experiment to test the comparative fertility of these plats with a view to their use for experimental purposes; (3) experiments with the "unknown" pea, a promising variety of cow-pea; (4) the filling of three silos with corn, sorghum, and soja beans.

Rotation plats.—Tests of uniformity and productiveness of soil of experimental field.—The following general account of these soil tests is taken from pages 53 and 54 of the report of the director:

> To secure a proper basis for future work, several acres were laid out in plats [16 rods long and 5 rods wide], and cultivated in even-growing plants, without manures, thus testing the uniformity and natural productiveness of the soil. [The land appeared to be quite exhausted.] On 6 half-acre plats yellow dent field corn was grown. The season was unfavorable for corn. The plats were harvested by quarter acres, 12 in number, each nearly square. The yields are given in tabular form. The product of field-cured stover ranged from 470 pounds to 774 pounds, or an average of 590½ pounds. This is at the rate per acre of 1,880 pounds to 3,096 pounds, average 2,362 pounds, of harvested stalks or stover. Eight of the plats were below the average in product and four above. The grain cured so poorly, owing to lateness of crop and unfavorable season, that it was evidently fairer to compare the total product of ears as husked than to divide into sound corn and soft corn. The total weight of ears per plat ranged from 250 to 519 pounds, the average being 382½ pounds; this was at the rate of 1,000 to 2,076 pounds per acre, and an average of 1,530 pounds. Computed at 70 pounds ears to the bushel, the average was almost 22 bushels of shelled corn per acre. Five plats were above average and seven below it. Making allowance for the missing hills and computing to a full stand does not materially affect the result. On twenty-seven plats each one-eighth of an acre (3⅜ acres in all), the soja bean was cultivated. Here the product ranged from 620 pounds to 1,386 pounds per plat, an average of 966½ pounds. This equals 4,960 pounds to 11,088 pounds per acre, average 7,732 pounds per acre. As explained in the record, the above figures include only 22 of the 27 plats, the rest having been reserved for seed. Eleven were above the average and the same number below.
>
> The results of these trials do not indicate that degree of uniformity in the soil desirable for field experiments, but the comparative record of production will materially aid in the interpretation or qualification of future results on the same plats.

Specimens of the soja bean plants were analyzed.

> From the above and other records, it may be stated that, when the soja bean and common red clover are compared ton for ton of green product at time of harvesting, the former gives more total dry substance or food, than the latter, and this in the form of more valuable nutrients. It has also been abundantly proved that land which will not produce enough clover to pay for cutting may yield an average crop of the soja bean.

Record of setting fence posts (p. 76).—Round posts of seasoned cedar were treated, before setting, with coal-tar, creosote oil, or crude petroleum, or were charred, or were set by different methods without special preparation. The object of the experiment was to test the comparative durability secured by the different methods used.

MINNESOTA.

Agricultural Experiment Station of the University of Minnesota.

Department of the University of Minnesota.

Location, Saint Anthony Park. Director, Edward D. Porter, Ph. D.

ANNUAL REPORT FOR 1888.

[The report of the Station is included in Supplement I to the Fifth Biennial Report of the Board of Regents of the university, pp. 51–408.]

Report of Director (pp. 53–69), (illustrated).—This includes an account of the history and organization of the Station. In 1868 the legislature of Minnesota authorized the Board of Regents of the university to expend $8,500 from the fund acquired under the act of Congress of July 2, 1862, in the purchase of an experimental farm. A tract of land near the university was secured, and under the direction of Professor Charles Y. Lacy, was used for experimental purposes up to 1880. Reports of the experiments undertaken during this period will be found in the reports of the Board of Regents for 1875–80. Professor Edward D. Porter succeeded Professor Lacy, January, 1881, and on his recommendation the old farm was sold and a new one purchased. By an act approved March 7, 1885, the legislature of Minnesota instructed the Board of Regents to establish an agricultural experiment station, but as the university had no funds for this purpose the reorganization of the experimental work was not completed until after the appropriations under the act of Congress of March 2, 1887, became available, which was not until February 1, 1888. The plan for the reorganization proposed by Professor Porter and that adopted by the Board of Regents are given.

In 1878 the legislature of Minnesota authorized the purchase of a tract of land on the shores of Lake Minnetonka, for the purpose of establishing an experiment station for the propagation, trial, and dissemination of new varieties of fruits adapted to the climate of Minnesota; and appointed Peter M. Gideon, Esq., the superintendent, and placed the management of the Station under the direction of the Board of Regents of the university. This Station has been in operation up to the present time, and reports of its work have been published in the biennial reports of said board. Mr. Gideon's final report will be found at the end of this volume.

In 1885 the legislature authorized the establishment, at Owatonna, in connection with the State school for orphans at that place, of an experiment station for the test and trial of hardy varieties of forest-trees, and also placed its direction under the control of the Board of Regents, but made no appropriations for its expenses.

This has been made a branch of the Agricultural Experiment Station. Four bulletins were issued by this Station during 1888.

REPORT OF AGRICULTURIST, E. D. PORTER, PH. D. (pp. 70–187), (illustrated).

Up to May 1, 1888, all the work of the Experiment Station devolved upon the director, consequently the reports of work in the departments of field and grain farming, stock, dairy, and horticulture are given by him under the general head of agriculture.

Notes on the experimental orchard of Russian apples (pp. 71–79).—These notes are made after three seasons' growth of the orchard and the tests of the severe winters of 1885–86 and 1886–87.

The result of the winter of 1885–86 on the Russians, as heretofore reported, was the death of 32½ per cent of the number planted. In the place of the 37 trees thus winter-killed, others were set, of varieties not before standing in the orchard.

The summer of 1886 was as favorable for tree growth as could be desired, and the trees were well matured when winter set in.

Notes are given on the condition of sixty-five varieties in August and November, 1887.

Of these varieties, not one started growth from terminal buds in the spring of 1887. Those which killed back one inch or less, and which, in such situations as are ordinally chosen for orchards, may fairly be presumed to be perfectly hardy in this latitude, are Green-Streaked, Voronesh Reinette, Flat Voronesh, Koursk Anis, Pointed Pipka, Titus, Gruchevka, Red Pipka, Aport Orient, Arkad, Yellow Calville, Heidhorn, Gipsy Girl (56 Vor.), Blushed Calville, Hibernal, and Ostrokoff's Glass.

It is not fair to assert, however, that the remainder of the list is too tender for culture in Minnesota; nor, on the other hand, can entire hardiness be claimed for the above list.

A list of the varieties of Russian apples which have been grown on the grounds of this Station, either in orchard or nursery, is given. We have about 3,000 young trees 2 and 3 years old, which will be distributed in the spring of 1888 in small quantities, for trial, to the several experiment stations of the State Horticultural Society, and to careful cultivators in each county of the State, for the purpose of testing the adaptation of these apples to the diversities of soil and climate found in Minnesota.

Experiments in wheat culture (pp. 80, 81).—A brief tabular record of experiments in 1886 and 1888 with spring wheat (Blue Stem) on thick and thin seeding (4 to 8 pecks per acre), deep and shallow planting (1½ to 5½ inches), and early and late planting (May 12 to June 30).

Experiments in potato culture (pp. 82–84).—A tabular record is given of an experiment with Early Rose potatoes, with reference to "the influence of quantity of seed and methods of cutting upon the time of ripening, and the productiveness of the crop." The tubers were planted whole and in halves, quarters, and two-eye pieces. The largest yield was with the "large seed, seed ends, cut in quarters." There is also a brief account of an experiment in the propagation of plants from two potatoes of a new variety, Polaris.

The following general résumé of experiments with potatoes at this Station is taken from the report:

During the season of 1887 we have continued the experiments of 4 years past, in the test of varieties, and had 370 under cultivation, and after 5 years' experience with these varieties, embracing all that are valuable in this country and Europe, I can but repeat the conclusions of my last report.

> (1) Out of the great number of varieties tested, but a few possess all the qualities desirable for a table or market potato in our State, however valuable they may be elsewhere. Among them I will mention as especially worthy of cultivation, Beauty of Hebron, Burbank Seedling, Chicago Market, Clarke's No. 1, Dakota Red, Early Household, Early Sunrise, El Paso, Garfield, Mammoth Pearl, White Star, White Elephant, and Snow-Flake.
>
> (2) Change of climate, soil, and season will not restore the lost stamina of the favorites of the past in which the diseases and defects of years of cultivation have accumulated.
>
> (3) Productiveness of quality of this tuber can only be secured by growing from the seed and developing new varieties, which by careful selection, cultivation, and crossing will be adapted to the peculiar conditions of the respective portions of our country.

Silos and ensilage (pp. 85–89).—This contains a description of the Station silos, a brief account of the crop of ensilage corn raised at the Station in 1887, the methods of harvesting the crop and filling the silo, and the calculated cost of growing and harvesting the corn and filling the silo. It is estimated that it cost 45 cents per ton to grow the corn and 43 cents per ton to harvest and store it in the silo. Particular attention is called to the following peculiarity in the construction of the Station silos:

> The sides do not extend to the bottom, but stop short 1½ inches all around. Before filling the silo a strip of tar paper is folded lengthwise and doubled, so that one half of it will lie against the wall and the other portion on the floor, and is held in place by a strip of board. This makes an air-tight joint when the pit is filled. When the ensilage is fed out this strip of board and the lining of paper are removed, and there is a free circulation of air around all the sides of the silo between the wall and lining, which keeps the woodwork dry and adds greatly to its durability. The air chamber provided by this method of construction has preserved the ensilage from freezing during the two past winters, although located on the north side of the barn and exposed to a temperature of 40 degrees below zero.

Comparative tests of varieties of corn for ensilage (pp. 90–98).—A tabular record of the results of analyses of 26 varieties grown at the Station, by J. A. Dodge, professor of chemistry in the university. Among the conclusions drawn from these analyses is the following:

> Comparing the different varieties of dent corn, we find that although the Southern Ensilage corn yields nearly double the quantity of fodder furnished by the Minnesota Dent, the Dakota Dent, Sibley's Pride of the North, Leaming, and Smedley, nevertheless when we take into consideration the short season required for their growth, their high nutritive values, and the saving in labor in handling the crop, we must give the preference to these varieties of medium-sized dent corn in Minnesota and the Northwest. Their superiority is much more evident when the fodder is dried for feeding than when used as ensilage, owing to the smaller growth of their stalks and consequent easier mastication by animals.

Facts concerning silos and ensilage (pp. 99–101).—Under this head is given the following summary of advice and opinion regarding silos and ensilage:

> (1) A silo is only a preserving can on a large scale, and the same conditions necessary for success prevail in both.

(2) A good silo may be built with very rough lumber and with ordinary labor by a liberal use of tarred building paper, the "pioneer's friend."

(3) The location, form, and construction of the silo, the arrangements for filling, covering, weighting, and feeding must be governed by local circumstances; but it is always better to fill above the feeding floor than below, as it is easier to elevate the ensilage at the time of harvesting, when it can be done by automatic machinery, than to do so day by day by hand through a long winter with the mercury below zero.

(4) Of whatever material the silo is built the walls must be perpendicular and the inner faces smooth, so that the ensilage may settle easily.

(5) The walls of the silo must be strong enough to withstand the lateral pressure of the inclosed mass.

(6) Water-tight and air-tight bottoms and air-proof walls are prime essentials in building a silo.

(7) It is advisable to divide the space intended for a silo into three compartments of equal size, so that they may be filled to the depth of 4 or 5 feet alternately, and thus allow time for fermentation to set in and the heat to rise to 125 to 140 degrees before again filling. This temperature aids in the digestion of the food, kills the germ which promotes fermentation, partially expels the air, and secures comparatively sweet ensilage.

(8) While any plant or vegetable fit for cattle food when green or undried may be preserved in the silo for an indefinite period, Indian corn is the cheapest and best for ensilage in this country.

(9) Plant such varieties of corn for ensilage as will reach maturity in an ordinary season in your section. Plant in rows wide enough apart to admit of easy cultivation, and just thick enough in the row to allow each stalk to form a well-developed ear.

(10) The best time to cut corn for ensilage is when the grains are fully formed and in the doughy or glazing state; the fodder then contains the largest amount of digestible matter.

(11) Corn partially dried before packing in the silo gives equally good fodder and at a reduced cost.

(12) The best results are obtained by cutting the ensilage into half-inch lengths, especially for well-grown and nearly matured corn stalks.

(13) In filling the silo, care should be taken to spread it evenly as put in, to pack the corners and sides firmly, to cover the top with a layer of boards or plank; spread over this a double layer of tar paper, and then a layer of rough boards, and on the whole a moderate weight of from 50 to 100 pounds to the square foot. The weighting material may be anything convenient—sand, gravel, or dirt in barrels, stone, firewood, farm implements, for storage and the like.

(14) Pits should not be opened until fermentation has ceased and the mass has cooled, which will be in from 6 to 8 weeks from the time of filling.

(15) In feeding from the silo, it is better to feed day by day from the top in uniform layers rather than from top to bottom, as by this method the surface is not exposed long enough to the air to become sour.

VALUE OF ENSILAGE.

(16) Ensilage can be grown and preserved much cheaper than root-crops by the ordinary farmer, and will successfully take their place in feeding value.

(17) Corn ensilage is not a complete feeding ration, as it is deficient in protein, and this must be supplied by some by-product as bran, shorts, or oil cake.

(18) The tests of the laboratory and the feeding stables do not agree as to the value of ensilage. The practical results of its use are so satisfactory as to surprise the chemist, and thus far he has failed to give them a satisfactory explanation.

(19) The best results of feeding ensilage are obtained by using it in combination with dry fodder, the best of which is clover hay.

(20) We do get more out of the silo than we put in it, for the reason that the chemical changes which take place in the process of curing are identical with those that take place in the first stages of digestion, and consequently there is a saving of vital energy to the animal and an economy of food consumption.

(21) Ensilage furnishes a succulent and easily digested food, greatly relished by all animals during the long winters of our Northwest, when they would otherwise be confined to an almost uniform ration of dry provender.

(22) The ease with which silos may be constructed, the certainty with which they will preserve food from injury, the low cost of raising and storing the crop, and it value as a cattle food, render this the cheapest provender a stockman can raise.

Examination of beets for sugar and for stock, J. A. Dodge (pp. 102–105).—Varieties of beet seed were imported and planted along with 3 other varieties of beets, 2 of mangel-wurzels, 1 of carrots, and 1 of parsnips. The results of analyses of samples of these are reported in tables.

Experiments in stock feeding (pp. 106–136).—Experiments were undertaken to get (1) light upon the comparative merits of cold and warm water for farm stock so far as relates to the amount of food consumed, and to the production of milk, butter, and beef; and (2) the relative values of corn ensilage, timothy hay, wheat bran, corn meal, and oil meal, in various combinations, as food for dairy stock and beef animals. They began in March, 1888, and continued until May, when the farm stock were turned out to pasture.

The following data were observed and recorded: the date of the experiment; Station number of the animal; age and breed; in the case of cows, the date of last calving and the date at which the next calf was due; the weight of the animal, taken at 11 o'clock daily; the temperature of the external air and of the air in the stables, recorded morning, noon, and night; the temperature and weight of the water drank and the weight of food consumed by each animal morning, noon, and night; the weight of milk given by each cow morning and night; the percentage of cream furnished by each cow's milk morning and night; the weight of the butter produced by each group of cows at each churning from the beginning to the end of the experiment.

There were required each day two hundred and twenty separate weighings, besides the work of recording, tabulating, and reducing the results. This work was accomplished by Professor Willet M. Hays, aided by his stableman, Mr. Charles Shultis, and the working force of the Station.

Equipment for feeding experiments (pp. 108–112).—Stables, work room, and office used for this purpose are described, with diagrams. The necessity for some convenient method of tabulating the daily records of such experiments led to the devising of a recording desk, "which has proved to be admirably suited to the purpose." This desk is described, with diagrams. There is also an account of a method of straining and carrying milk. The carrying pail used is described in detail, with illustrative cuts.

Ensilage vs. timothy hay for dairy cows (pp. 112–119).—An experiment with ensilage *vs.* timothy hay as food for dairy cows was combined with one on the effects of warm *vs.* cold water. Six cows, two each of Holstein-Friesians, grade Ayrshires, and natives were divided into two groups of three cows, one of each breed. The cows were nearly alike as to weight, time since calving, daily milk yield, breeds, etc. Group 1 received warm water, 70° Fah., and group 2 cold water, 30° Fah. The feed of the previous winter had been ensilage, hay, and bran for a preliminary period, from March 1 to 21, inclusive, during which period a record of the milk yield was kept. A transition was then made to the ration of the first period of the experiment, which consisted of 14 pounds timothy hay, 7 pounds bran, 4 pounds corn meal, and 3 pounds old-process oil meal. This was calculated approximately to Wolff's daily standard for milch cows, live weight 1,000 pounds, using analyses and tables of digestibility given in Armsby's Cattle Feeding. After this period of 17 days followed a transition period of 7 days, during which ensilage was substituted for the hay. During the second period of the experiment of 17 days the ration was 35 pounds of Southern corn ensilage, "about as much ensilage as the cows would eat, and with it enough of the grain feed to make as good a ration as given during the first period." A transition period of 9 days followed, in which the ensilage was replaced by hay. So that the ration for the three periods was the same as for the first. Owing to sickness one cow of each group was removed during this period, and other circumstances caused the termination of the third period at the end of eight days.

No analysis was made of the milk or of the fodder, except the green corn from which the ensilage was made. An indication of the character of the milk was found in percentages of cream and in the butter product. "The cows were fed thrice daily what they were quite sure to eat clean, and occasionally small amounts were weighed back so as to always have a clean manger for fresh food. * * * Records were kept of the amount of food given each animal and that weighed back at each feeding." Although this series of experiments was made late in the season and regarded only as preliminary to others planned, some of the statistics given in the report are here quoted:

Results of period 1, from March 22 to April 7.

TIMOTHY HAY, WHEAT BRAN, CORN MEAL, OIL MEAL.

Cows. Group.	Station No.	Water drank.	Food eaten.	Milk given.	Cream.	Weight. Beginning.	Weight. Ending.	Gain or loss in weight.	Butter produced.	Milk to 1 pound butter.	Food to 1 pound butter.	Food to 1 pound milk.	Butter to 100 pounds milk.
		Lbs.	*Lbs.*	*Lbs.*	*P.c*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs. ozs.*	*Lbs. ozs.*	*Lbs. ozs.*	*Lbs. ozs.*	*Lbs. ozs.*
I. Warm water.	88	1,454	481	162	11	969	1,021	+52	....	....	....	....	....
	61	1,922	585	321	14	1,100	1,098	—2	....	....	....	....	....
	42	2,515	730	563	11	1,305	1,331	+26	....	....	....	....	....
Total group I.	....	5,891	1,796	1,047	..	3,374	3,450	+76	39 11	26 7	45 5	1 11½	3 12
II. Cold water..	16	1,919	656	317	8	1,238	1,294	+56	....	....	....	....	....
	65	1,798	584	424	12	1,052	1,072	+20	....	....	....	....	....
	76	1,853	583	415	12½	960	1,002	+42	....	....	....	....	....
Total group II	....	5,570	1,823	1,156	....	3,250	3,368	+118	42 0	27 8	43 5	1 9	3 10
Total........	....	11,461	3,619	2,203	....	6,624	6,818	+194	81 11	*26 14	*44 5	*1 10	*3 11

*Averages.

An increase in milk yield was expected, but instead there was a falling off in this regard and an unusual gain in weight. This comparatively rich grain ration was made to produce beef rather than milk and butter—a very unprofitable thing for dairy cows to do when already in good condition. We had doubled or trebled the cost of food over that upon which the cows had been previously wintered, and the gains came only in the form of beef. Nearly 2½ as many pounds gain in live weight were produced as the whole of the butter churned during this period. * * * The relatively small amounts of butter from 100 pounds of milk was a surprise.

Results of period 2, April 14 to 30 inclusive.

ENSILAGE, WHEAT BRAN.

Cows. Group.	Station No.	Water drank.	Food eaten.	Milk given.	Cream.	Weight. Beginning.	Weight. Ending.	Gain or loss in weight.	Butter produced.	Milk to 1 pound butter.	Food to 1 pound butter.	Food to 1 pound milk.	Butter to 100 pounds milk.
		Lbs.	*Lbs.*	*Lbs.*	*P.c.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs. ozs.*	*Lbs. ozs.*	*Lbs. ozs.*	*Lbs. ozs.*	*Lbs. ozs.*
I. Warm water.	88	1,050	819	112¾	10½	1,037	1,019	—18	....	....	....	....	....
	61	1,259	940	350	12	1,102	1,504	—48	....	....	....	....	....
	42	1,864	1,330	442	11½	1,333	1,347	+14	....	....	....	....	....
Total group I.	....	4,173	3,089	905	....	3,472	3,420	—52	31 10	28 10	97½	3 7	3 8
II. Cold water..	16	1,499	1,121	312¼	5	1,298	1,282	—16	....	....	....	....	....
	65	*825	691	228	11¾	1,054	1,047	— 7	....	....	....	....	....
	76	1,290	1,042	364¼	13	889	1,008	+19	....	....	....	....	....
Total group II	....	3,614	2,854	905	....	3,341	3,337	— 4	32 4	28 1	88½	3 2	3 9
Total........	....	7,787	5,943	1,810	....	6,813	6,757	—56	63 14	†28 5½	†93	†3 4½	†3 8½

* Three days before the end of the second period No. 65 was thrown out of the experiment on account of sickness.
† Averages.

In period 2 there was a loss in weight, also a decrease in both milk and butter. Practically stated, the hay did more good than two and one-half times its weight of this ensilage, or all the ensilage the cows would eat in place of the hay. * * * The corn ensilage used was made from the largest Southern variety, grown under conditions to make the largest possible growth, and by actual weight produced 35 tons per acre.

Results of period 3, May 10 to 17 inclusive.

TIMOTHY HAY, WHEAT BRAN, CORN MEAL, OIL MEAL.

Cows. Group.	Station No.	Total water.	Food eaten.	Milk given.	Cream.	Weight. Beginning.	Weight. Ending.	Gain or loss in weight.	Butter produced.	Milk to 1 pound butter.	Food to 1 pound butter.	Food to 1 pound milk.	Butter to 100 pounds milk.
			Lbs.	*Lbs.*	*P. ct.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs. ozs.*	*Lbs. ozs.*	*Lbs.*	*Lbs. ozs.*	*Lbs. ozs.*
I. Warm water.	61	862	201	131½	12	1, 005	1, 018	+13	....	....	....	....	....
	42	1, 202	350	216	12	1, 330	1, 366	+36	....	....	....	....	....
Total group I..	....	2, 064	551	347½	.....	2, 335	2, 384	+49	11 11	29 11	47	1 9	3 6
II. Cold water.	16	1, 056	349	150½	8	1, 315	1, 343	+28	....	....	....	....	....
	76	802	223	176	13	1, 000	1, 000	.....	....	....	....	....	....
Total group II.	....	1, 858	572	326½	.....	2, 315	2, 343	+28	10 8	31 1	54	1 12	3 1
Total..........	....	3, 822	1, 123	674	.....	4, 650	4, 727	+77	*22 3	*30 2	*50	*1 10	*3 3

* Averages.

In period 3 the production of milk again fell off abnormally. The same tendency to produce fat rather than milk and butter, which occurred when hay was fed the first time to cows accustomed to ensilage, was again observed. * * * Though this last period was more or less unsatisfactory because of removing two cows, the proportionate value of hay over two and one-half times its weight of this ensilage would have been overestimated had we stopped at the end of the second period. The one fact standing out prominently is, that the hay and grain ration produced an unusual and undesirable increase in live weight, while the ensilage and grain ration went more to milk, and even allowed a slight decrease in weight.

Warm vs. cold water (pp. 119-121).—The average temperature (Fah.) outside and within the stable, respectively, were, in period I, 24½ and 26½°; in period II, 40 and 52½°; in period III, 42 and 52°.

Much significance can not be attached to the fact that the weather was colder in the first than in later periods, as the cows were comfortable nearly all the time and were not exposed to storms. * * * Much less cold water was drank per 1,000 pounds live weight than of warm water in all the periods, one instance excepted, and less was drank when ensilage was fed than when hay was given, even if that used in moistening the hay is not counted (see last column of the tables). In the last period, when the average temperature outside was 42° and inside 52°, one-tenth more warm than cold water was taken. * * *

Quantities of water drank.

Group.	Period.	Total water given.	Daily average weight of group.	Daily average drank per 1,000 pounds live weight, including that used in moistening hay.	Daily average drank per 1,000 pounds live weight, not including that given in feed.
Warm water	1	5, 891	3, 387	104	89
	2	4, 173	3, 443	71	71
	3	2, 064	2, 366	109	99
Cold water	1	5, 570	3, 311	99	90
	2	3, 614	3, 354	63	63
	3	1, 858	2, 334	99	88

As will be noticed from the table, there is no marked advantage for either the warm or cold-water group. Taking the total quantities of food, milk, and butter, the advantage appears on the side of the cold water.

Gains and losses in live weight (p. 122).—The two Holsteins gave comparatively small amounts of milk of very poor quality and converted most of the rich food into profitless beef. Both increased in weight for the whole time and for each period, excepting No. 16 during the second period. The two natives also gained during the total time and during each period, excepting No. 88 for the second period. Of the Ayrshire grades, No. 61 decreased in weight, except during the last period. No. 65 gained during the first period and then fell off rapidly. * * * The following table shows the weights and gains or losses by periods, also for the entire time, for each animal and for the two groups.

Apparent gains or losses in live weight with different rations and with warm vs. cold water.

Cows.		Period 1. Hay and grain.	Period 2. Silage and grain.	Period 3. Hay and grain.	Entire time.*
Group.	Station No.				
I. Warm water	88	+52	−18	....	+34
	61	−2	−48	+13	−52
	42	+26	+14	+36	+62
Total group I	....	+76	−52	+49	+43
II. Cold water	16	+56	−16	+28	+105
	65	+20	−7	....	−5
	76	+42	+19	00	+40
Total group II	....	+118	−4	+28	+140

* The last column, "Entire time," includes the two weeks of preliminary feeding before the second and third periods, and on this account is not the sum of the previously given gains and losses.

Corn meal vs. wheat bran (pp. 123–136).—An experiment to compare corn meal and wheat bran in feeding for beef was undertaken with four grade Brown Swiss steers, but the condition of the animals at the beginning of the experiment seems to have been such as to have rendered the test unsatisfactory and incomplete. A daily record of the feeding experiment with the cows and steers above described is given in tabular form, and includes data for the temperature in and outside the stable, weight of animals, food eaten, water drank, and in the case of the cows milk given and per cent of cream.

Experiments with commercial fertilizers (pp. 137–160).—A field of about 13 acres was chosen for experiments with commercial fertilizers. The soil is rich, and the subsoil down to the gravel at the depth of about 6 feet contains considerable clay. The land has been cultivated some 30 years, wheat being the crop grown. In the spring of 1888 the field was divided into ten strips, each about 50 feet wide, running east and west. Eight of these were treated with different fertilizers, and two left unmanured. The field was also divided by lines running north and south, into eleven strips, each about 88 feet wide. On these as many different crops were put. There were thus 110 plats, each about one-tenth of an acre. They were separated by alleyways three feet wide, which were kept thoroughly cultivated during the season. In other words the field was divided one way into strips, on which the different fertilizers were applied, and at right angles in the strips carrying different crops, so that each crop was tested with each fertilizer. The crops grown were Wellman's Fife and Blue Stem wheat, Welcome and Probsteier oats, Black and Manshury barley, peas, flax, White Star potatoes, Monarch mangels, and beets. Grasses and clovers were sown with the green crops, and several varieties of sugar-beets, carrots, and parsnips were also planted.

Fertilizers.—Sulphate of potash, superphosphate, and nitrate of soda were used in combination on two plats; sulphate of potash and superphosphate, sulphate of potash and nitrate of soda, superphosphate and nitrate of soda, nitrate of soda alone, air-slacked lime, and common salt were used on as many different plats. Two plats received no manure. Detailed notes are given of the growth and yield of the crops on the different plats. Specimens of the sugar-beet were analyzed by the chemist of the Station with reference to their sugar content, but no relation between the fertilizers and sugar content was observable.

Results.—Assuming that other conditions were uniform so that the difference in yield was due to the fertilizers, some of the results of this experiment may be stated as follows:

As to amount of produce.—Nitrogen in the form of nitrate of soda had the effect of increasing the growth of young wheat, oats, and barley plants, so that they were better able to withstand the attacks of chinch-bugs. What effect it might have had on the yield of grain in the case of wheat and barley could not be determined, as the chinch-bugs prevented their ripening. Nitrate of soda increased the weight of oat straw over one-half ton per acre, and of grain 3 bushels per acre; probably this increase in grain was due to the ranker growth of straw, where nitrogen was scattered, being less favorable to the chinch-bugs. Three hundred pounds per acre of nitrate of soda more than doubled the weight of flax straw but did not increase the yield of flaxseed one-half bushel per acre. Seven or eight bushels per acre less of potatoes were grown on the plat treated with 300 pounds nitrate of soda than on unmanured plats. Nitrogen increased the yield of mangels 2½ tons per acre. Clover produced many flowers and seeds on plats not fertilized with nitrogen, but on all those upon which nitrate of soda was placed very few flowers were formed, though the leaves grew nearly or quite as strong. It has long been known that nitrogen increases the growth of straw more than grain. But in this case the clover was kept from producing seeds by the application of nitrogen.

Sulphate of potash and superphosphate applied together, caused an increase of one-fourth ton per acre of oat straw and flax straw, but no more grain. These two fertilizers caused no increase of potatoes, beets, or mangels.

Lime caused no increase of oat or flax straw, or oats, but in this single trial increased the yield of flaxseed 1 bushel per acre. Lime lessened the quantity of potatoes and beets.

Fifty bushels of salt increased the yield of oats 5 bushels per acre, and of oat straw 200 pounds; of flaxseed 1½ bushels, and of flax straw 500 pounds; and of beets 1½ tons per acre. No increase of potatoes was produced by salt.

As to quality of crops.—Salt and lime produced heavier oats. Sulphate of potash and superphosphate made no difference in the quality of the oats. Nitrate of soda caused the oats to weigh less to the bushel than on unmanured plats.

Flax weighed 3 or 4 pounds heavier per bushel on plats manured with nitrate of soda; other fertilizers made no difference in the quality of flax.

Potatoes were not bettered in quality by the use of either nitrogenous, potash, or phosphatic fertilizers. Salt seemed to increase the size of the tubers, while lime was injurious in this respect.

Beets were slightly increased in size by nitrate of soda; lime made them smaller. No difference in the size of the beets was produced by the other mineral fertilizers.

None of these fertilizers caused enough increase to pay the cost of their application. * * *

Practical conclusions.—The facts and figures given in this report are worthy of study by every farmer in Minnesota. It will be remembered, of course, that these experiments apply to only one "wheat sick" farm, and to other farms in the State they apply only in a general way.

The most valuable advice that farmers in Minnesota can listen to on this subject is that concerning the making and saving of home-made manures.

Keep stock; feed them well on feeds rich in nitrogen and mineral manures; carefully save and return to the soil both the solid and the liquid excrement; practice rotation of crops, taking crops of wheat off the land only once in three to six years. Raise clovers and grasses in rotation with grain or other crops; pasture and feed these. Remember that clover roots as well as tops make much rich manure. Buy fertilizers in the form of bran, shorts, etc., allowing milch cows and other profitable stock to take "toll" from these while turning them into manure, but do not allow the rain to take out the most valuable parts while running through the manure from the eaves of the barn. Rot the manure properly, without waste, or if you can not do this, haul it directly from the stalls and sheds to the fields.

Varieties of sorghum (pp. 161–163).—Notes on 18 varieties grown with a view to finding varieties which ripen early enough to be useful in Minnesota. Early Tennessee, Honey Dew, Swan's Early Golden, and Early Amber were among those which gave the best results this season.

Methods of preparing ground for oats (pp. 164–166).—Three different ways of preparing corn-stubble ground for oats were compared, viz., fall plowing, spring plowing, and "cultivating in" without plowing.

The spring-plowed plat did not yield as much grain per acre, thus adding proof to the general belief among farmers, that spring plowing is not nearly so good for oats or other small grains as fall plowing, or even as pulverizing the surface of the soil by means of the disk harrow or other equally good pulverizer.

Grasses, clovers, and other forage crops (pp. 167–187).—The Station has begun a series of experiments with a considerable number of varieties of grasses, clovers, and other forage crops, with a view to determining their value for this section.

Experiments are in progress to test the various mixtures of grass and clover seed for longer and shorter "lays" adapted to certain rotations of crops, and the several kinds of farm animals. It is desirable to find methods of seeding some of our most valuable native grasses, and farmers are requested to gather seeds of good grasses growing in their localities, and send them here, to be sown upon plats where their growth can be compared with the many kinds already in cultivation.

This article includes notes on the experiments at the Station, and general notes regarding orchard grass (*Dactylis glomerata*), timothy or herd's grass (*Phleum pratense*), Kentucky blue-grass or June grass (*Poa pratensis*), redtop (*Agrostis vulgaris*), perennial rye-grass (*Lolium perenne*), tall meadow oat grass (*Arrhenatherum avenaceum*), tall or meadow fescue (*Festuca elatior* or *F. pratensis*), sheep's fescue (*Festuca ovina*), brown bent or fine top (*Agrostis canina*), red clover (*Trifolium pratense*), mammoth clover (*Trifolium medium*), alfalfa or lucern (*Medicago sativa*), alsike clover (*Trifolium hybridum*), and white clover (*Trifolium repens*). There are also brief notes on experiments with 47 varieties of grasses, clovers, and forage plants, and on two lawn mixtures experimented with.

ROOTS OF CLOVERS, W. M. HAYS, B. S. A. (pp. 188–197), (illustrated).

> The general belief among farmers is, that the roots of our ordinary field plants do not reach a length of more than 1 or 2 feet, and many inaccurate and misleading statements have been published from time to time in this regard. One corn root which I washed out the past season extended in a nearly horizontal direction 5 feet from the stalk, and there turning down was followed to the depth of 3 feet, where it was broken and lost. * * * I have traced roots of pumpkins more than 10 feet away from the vine. Many observations have proven that 4 to 6 or more feet in length is not unusual with the roots of most farm crops.

Illustrations given in the report show that there is quite a marked difference in the roots of the several species of clover as well as in those of different plants of the same species. "Some red clover plants, for instance, have a large central root, or 'tap-root,' while others have small central roots, which at the depth of a few inches are no larger in diameter than some of the branching roots and do not go as deep. The chemical and physical character of the soil modifies or directs, to a great extent, the methods of growth of the roots of plants."

What is wanted in Minnesota is a hardy red clover which is thoroughly perennial. And since the vitality of a plant depends upon the roots and crown, a study of these parts should precede any attempt to originate new varieties by selection and cross-fertilization.

> The power of red clover to live through the winter depends, in a great measure, upon the time the plants have had in the fall to lay up a rich store of food material in their roots, crowns, and buds. The "stand" of clover plants may sometimes be ruined by pasturing close and late, cutting very late, or allowing the plants to produce seeds just before the winter stops growth, thus compelling the plant to hibernate with not enough stored-up food to enable it to start into vigorous growth in the spring before the soil has reached a temperature at which it can assimilate inorganic food from the soil. * * *
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> Last spring (1888) I planted seeds of red, mammoth, alsike, and white clover; also alfalfa or lucern, so as to raise individual plants, with no others closer to them than a few feet. A dozen of each were thus planted on plats 5 feet by 16 feet in area, and small stakes placed by the seeds to indicate their locality. The weeds were kept from growing, but the soil was cultivated very shallow, so as not to disturb their roots. The soil in which they were planted is in a "hollow," and is a rich drift soil, composed of clay, sand, and loam. At the depth of about 6 feet it is underlaid with sand and gravel, the upper part of which is cemented into a crust that is almost impervious to the roots of the clovers. A foot or more of the soil is quite mellow, while farther down the clay subsoil is tough, as shown while trying to wash out some roots with a jet of water. The season was rather moist, the soil rich, and as the plants grew isolated they had a very good opportunity for growth.
>
> The seeds were planted May 15. On June 15, July 15, and about the middle of October, or when 1, 2, and 5 months old, two plants of each kind were carefully dug and sketches were made of the stems and roots.

Red clover.—When the plant was 1 month old the principal root extended downward 7 inches, while the side roots were only 2 or 3 inches long. When 2 months old the plant was 8 inches high, and several roots went nearly 2 feet deep. When 5 months old the plants were a foot or more high, while the roots had penetrated to the depth of 5 feet 8 inches.

The tap-root did not go quite so deep as some of the branching roots, and its point was found at the depth of 5 feet 6 inches. Below the depth of a foot and a half the roots were not as large in diameter as the lead in a common lead pencil, and gave off comparatively few branches. No such prominent tap-root as is usually described was found.

Mammoth clover.—The plant selected for the illustration at 1 month old was 1½ inches high. It had no distinct tap-root, but five main branches 5 to 7 inches long. When 2 months old this plant had a dense growth of leaves 5 inches high, but no stems. The roots were nearly 2 feet long, the tap-root being much less prominent than in the case of the red clover. At 5 months old it had produced no flowers, but the stems stood 7 inches high, and there was a dense growth of radical leaves; the deepest root was 4 feet 9 inches.

Alsike clover.—When 1 month old several plants of this species were 2 inches high. The one from which the illustration was made had a tap-root 9½ inches long and side roots of 2 inches or less. At 2 months the plants were 6 inches high, and the roots went more than 2 feet deep. At 5 months the stems were nearly a foot high, but owing to the procumbent habit some of them reached 2½ feet from the crown. The tap-root was not prominent, and at the depth of a foot or less was equaled in diameter by several of the side roots. "At the same age and under the same conditions, plants of alsike produced a greater mass of roots than either the red or mammoth clover."

White clover.—At one month the plants of this species had a tap-root 4½ inches long with numerous branching side roots. At 2 months the tap-root was 2 feet long and bore many branches. At this time another set of roots had begun to spring from creeping stems in a nearly vertical direction. At 5 months the plants covered a circular space 2 or 3 feet in diameter with a thick mat of stems, leaves, and flowers, about 5 inches deep. The tap-root was small as compared with other species of clovers at this age.

This original root system, of which the tap-root is the main part, dies in 1 or 2 years, and the older part of the stem dies leaving the runners disconnected from the original plant. While other clovers must depend alone on the perennial nature of their crown and central roots and on reseeding, these runners of the white clover, being supplied with roots for themselves, keep the original plant alive from year to year by this non-sexual but very certain method of reproduction.

Alfalfa.—At 2 months the alfalfa plants were 10 inches high and the roots nearly 3 feet long, consisting of a very prominent tap-root with comparatively small branches. At 5 months the tops were 16 inches high and the tap-root extended to a depth of 6½ feet. Some of the large side roots went down nearly as deep, and small side roots were observed which had branched off at the depth of more than 5 feet.

An illustration of an alfalfa plant grown in a very compact red clay soil is reproduced from Bulletin No. 60 of the North Carolina Station, to show how roots of plants may be modified by the kind of soil in which they grow. In this case the longest roots extended only 15 inches downward, while most of the roots were grown within 8 inches of the subsoil. Grown in such soil alfalfa will not endure drought or yield large crops.

REPORT OF HORTICULTURIST, S. B. GREEN, B. S. (pp. 198–299).

The horticultural department of the Station was established in the spring of 1888. "At that time an allotment of land for its exclusive use was made. It has required the whole past season to arrange for carrying on the future experiment work of the department."

Experiments with Russian apples have been in progress at the Station for four years. Thirteen hundred trees, including 260 varieties, are being grown in the orchard, located on rich soil in a very exposed position. The trees have as yet produced no fruit and the observations have, therefore, been confined to their hardiness and freedom from diseases. Thus far they "have made an excellent growth and ripened their wood perfectly." Two varieties of Russian pears, Bessimianka and Waxen also did well.

Preparations are being made to plant a large assortment of Russian pears and also an orchard of Russian cherries and plums. Russian willows and poplars are also being grown with especial reference to their use for wind-breaks. *Populus certinensis* and *Salix laurifolia* are mentioned as especially desirable for this purpose. Nearly 150 packages of nursery stock, consisting of an assortment of Russian apples, willows, and poplars, and some grape-vines, in all amounting to about 5,000 plants, were distributed by the Station in different parts of the State. It is the purpose of the Station to continue and enlarge this feature of its work. Novelties in seeds and plants will be tested and germination tests of seeds will be made. Tests of vegetables were made in 1888. The Station vineyard planted in 1887 has grown well. Tests of varieties of grapes and experiments with methods of pruning are planned, and a new greenhouse has been erected at the Station.

Insecticides and fungicides on potatoes, D. N. Harper, Ph. D. (pp. 203–208).—A record of experiments with Bordeaux mixture, Paris green, London purple, eau celeste, kerosene emulsion, "peroxide of silicates," "slug shot," and cassia. The chemical composition of samples of the several insecticides used is also given as determined by the chemist of the Station.

New greenhouse (pp. 209–217), (illustrated).—The new building and its equipments are described, with illustrations of the exterior of the greenhouse, its ground plan, and sections of the outside walls, and of six experimental walls built in one portion of the house.

Grapes (p. 218).—Tabulated notes on the ripening qualities of 19 varieties of grapes marked on a scale of 10.

Differences in the seeds of Minnesota grapes (pp. 219–222), (illustrated).—This contains brief descriptive notes on the Northern fox grape (*Vitis labrusca*), native brown grape (*Vitis cordifolia*), and the European wine grape (*Vitis vinifera*), from which have come the varieties of grapes successfully cultivated in Minnesota, and illustrations of the seeds of 12 varieties of grapes grown in Minnesota.

Russian willows and poplars from hard-wood cuttings (pp. 223, 224).—A brief account of an experiment begun in 1887, and tabulated notes showing the amount of growth and per cent of cuttings growing in the spring of 1888, for 12 varieties of poplars and 6 of willows.

Onions, effects of fertilizers and tillage (pp. 225–229).—In this experiment sulphate of potash, nitrate of soda, superphosphate and sulphate of potash together, and stable manure were compared with no manure on 5 plats. One-half of each plat was plowed 8 inches deep and harrowed, and the other half was only harrowed. The soil used "was an open clay loam, which had previously been used for garden purposes and had been highly manured." The details of the experiment are given in two tables. As regards fertilizers, the results were inconclusive. That portion of the plat which was only harrowed produced more and better onions and required much less weeding than that which was plowed.

Potatoes, methods of cutting and depth of planting (p. 230).—A tabular record of an experiment on 14 plats, in planting whole tubers, halves, quarters, and two-eye pieces on the surface, 3 and 8 inches deep, and on a 3-inch ridge.

Small fruits (pp. 231–236).—Notes on 3 varieties of strawberries and a list of 61 varieties added to the Station collection in 1888; notes on 6 varieties of raspberries and 3 of blackberries; a list of 22 varieties of raspberries, 16 of blackberries, and 2 of dew-berries; notes on 7 varieties of currants and 2 of gooseberries.

Vegetables (pp. 236–263).—Tabulated notes, with special mention of particular varieties, for the following vegetables (the kinds mentioned by name were deemed worthy of special mention): onions, 47 varieties, including Danver's Yellow, Red Wethersfield, Early Red or Early Red Globe, Large Red, and New Queen; peas, 56 varieties, including Maud S, Early Daniel O'Rourke, Caracticus, American Wonder, American Champion, Champion of England, and Yorkshire Hero; sweet-corn, 18 varieties, including Cory, Moore's Early Concord, Squantum, Egyptian, Triumph, and Roslyn Hybrid; carrots, 21 varieties, including Danver's, Oxheart, French Forcing, and Belgian; beets, 19 varieties, including The Lentz and Eclipse; musk-melons, 33 varieties, including Christiana, Baltimore, Montreal Market, and Surprise Musk; water-melons, 35 varieties, includng Dark Icing or Ice Rind, Phinney's Early, Ice Cream, Colorado Preserving, Volga, and Green and Gold; squashes and pumpkins, 24 varieties, including Hubbard, Marblehead, Low's Bay State, and Early Orange Marrow squashes, and Nantucket and Sugar Pumpkin pumpkins; salsify or vegetable oyster-plant, 7 varieties; asparagus, (5 varieties are named as grown at the Station, but no results are given); upright or tree tomato (no ripe fruit was obtained from this variety); kohl-rabi, notes on 5 varieties, which the author thinks quite desirable; martynia, successfully grown for pickles; top or perpetual onion, recommended for marketing in a green stage.

Vegetable list.—The Station proposes each year to publish a list of vegetables considered to be the best for the market and home garden. "This list we mean to have sufficiently conservative to be reliable, and progressive enough to be up with the times. We mean to recommend only those varieties which have been thoroughly tested."

The following list is given in this report:

Beans.—Dwarf: Golden Wax and Mont D'Or, for snap beans; Horticultural Dwarf, for the best dwarf shell bean. *Pole beans:* Dreer's improved Lima and Horticultural, for shell beans.

Beets.—Early: Eclipse. *Late:* Improved Long Red and Bastian's Blood Turnip.

Cabbages.—Early: Henderson's Early Summer (large), Jersey Wakefield (small). *Second early:* Fottler. *Late:* Fottler and Flat Dutch.

Carrots.—Earliest: French Forcing and Early Scarlet Horn. *Main crop for table use:* Danver's and Long Orange. *Main crop for stock:* Danver's and Large White Belgium.

Cauliflowers.—Snow-ball and Early Dwarf Erfurt.

Celery.—Early market: White Plume. *Best for general crop:* Golden Dwarf.

Sweet-corn.—Earliest: Cory. *Second early:* Moore's Concord, for market; Crosby's Early Sugar, Potter's Excelsior, and Black Mexican, for family use. *Late:* Stowell's Evergreen and Egyptian, for market and family use.

Cucumbers.—For early table use: Early Russian. *For early market use:* Early White Spine. *General market cucumber:* White Spine. *General table use:* Tailby's Hybrid. *For pickles:* Green Prolific and Boston Pickling.

Dandelion.—Large Leaved Doubled.

Endive.—Green Curled.

Lettuce.—For family and summer lettuce: Black-Seeded Simpson. It is also the best market variety where loose leaves and not heads are wanted. *For early market use:* Where heads are wanted, use Black-Seeded Tennis Ball. *For forcing:* Where loose leaves only are desired, use Black-Seeded Simpson. If for shipping, or where appearance only is wanted, use Boston Curled, which is one of the easiest to force, the best to ship, and presents a fine appearance. For best head forcing lettuce, use White-Seeded Tennis Ball.

Musk-melons.—For family garden: Christiana, Jenny Lind, Surprise. *For market:* Hackensack, Montreal Market, and Nutmeg.

Water-melons.—For family garden: Ice cream, Mountain Sprout, Dark Icing. *For marketing:* Dark Icing or Ice Rind, and Phinney's early.

Okra.—Dwarf green.

Onions.—For early bunching: White Globe. *For general crop:* Yellow Round Danver's or Early Red Globe or Red Wethersfield. *For white pickles:* White Portugal.

Peas.—First early varieties for market: Daniel O'Rouke, First of All, and American Wonder. *Second early for market:* McLean's Advancer. *First early variety for family use:* American Wonder. *For general late use:* Blue Imperial and Champion of England.

Parsley.—Henderson's Emerald.

Peppers.—Bell or Bullnose and Sweet Mountain.

Pumpkins.—Best for table use: Nantucket Sugar and Cheese. *Best for stock:* Connecticut Field.

Spinach.—Thick leaved.

Squashes.—Early summer variety for family use: Summer Crookneck. *Early summer for marketing:* Early Bush Scallop. *Best fall squash:* Boston Marrow. *Best winter:* Hubbard.

Tomatoes.—Best early: Canada Victor. *Best for general crop:* Perfection. *Best for late use:* Trophy.

Turnips (English varieties).—*Best early:* Milan Strapped-Leaf. *Best late:* White Egg, White Globe, Yellow Globe-

Swedes or ruta-bagas.—For general use: Improved American Swedish Turnip.

The dandelion as a market crop.

Of this there are two varieties, the common and the improved broad-leaved; the latter is much the larger of the two and the most profitable to grow. This is a very profitable crop when carefully cultivated and where there is a near market. It also forms excellent greens for the farmer's early garden. Those who are only acquainted with this vegetable in a wild state will be wonderfully surprised with the merits of the cultivated dandelions. The labor of raising them is comparatively easy and the satisfaction of having plenty of nice greens early in the spring well repays the little labor required to grow them. * * * Immense quantities of these greens are grown in the vicinity of large cities in the Eastern States.

The methods of cultivating dandelions are described in this article.

Boxes vs. baskets for gardeners (pp. 264–266).—Considerations regarding the advantage of the bushel box over the bushel basket for market gardeners are presented, with a view to encouraging the use of the former in Minnesota.

The advantages of the bushel box are:

The building of a solid load that binds well together.

More bushels can be put on a wagon when packed in boxes then when packed in baskets.

The vegetables or fruits in a bushel box always appear to more advantage and show off better than when in a basket.

It is a more uniform package and less liable to be made smaller than standard size.

Cabbages (pp. 267–273).—A history of this plant and accounts of methods of cultivation and the varieties best adapted to that section; and the insect pests of the cabbage, with suggestions as to remedies.

Bulletin No. 3 (pp. 274–296).—A reprint of the accounts of horticultural work published in Bulletin No. 3 of the Station. In the introduction an outline of the work in horticulture is given. This includes experiments in the methods of planting and cultivation of vegetables, tests of varieties of vegetables and fruits, especially Russian apples, pears, and plums; experiments in pruning, grafting and girdling grapevines; tests of Northern seeds; tests of Northern seeds as compared with those grown in the South and California; experiments with insecticides and fertilizers.

The Russian orchard (pp. 277–282).

This was planted in the spring of 1885 to demonstrate how far the Russian apples are adapted to the climate of Minnesota. The nursery is located on the open prairie, in a very rich soil. The original plantation consisted of 130 trees, embracing 65 varities of Russian apples. Fifty-two Duchess trees were also planted to afford a basis of comparison. These trees have been replaced by new varieties whenever they have proved themselves too tender for the conditions imposed.

Tabulated notes on the growth and hardiness of the different varieties of Russian apples are given.

Of the trees originally planted, 50 per cent of the Russians are alive, many of them in a very promising condition. Of the Duchess originally planted, 50 per cent are still alive, but most of them are very weak and poor. It is fair to suppose where two trees of a kind are dead, that the tree is at least of doubtful hardiness. It is quite probable that some of our Russians as they mature will become hardier. The following are the most promising of our Russian varieties:

177 Green-Streaked.
457 Kleuvskoe.
187 Green Glass.
361 Pointed Pipka.
599 Romenskoe.
282 Voronesh Reinette.

83 Pear.
200 Red Repka.
Aport Orient.
109 Vor.
447 Keiv Reinette.

210 Wine Rubets.
203 Arcad.
21 Vor. Yellow Calville.
22 M. Blushed Calville.
984 Koursk Anis.

Conclusions.—While many of our Russians have died, yet there are many remaining which are very promising and 16 which would be called good trees in any orchard. From this experiment we have found 16 varieties out of 65, or 24 per cent of those planted, which have withstood this severe climate for 3 years, with very little or no killing, and very many others that have done better than the Duchess. It seems to me from careful observation that we have much to hope for from our Russian apples.

Conditions of trees, shrubs, and vines in the nursery after the winter of 1887–88 (pp. 283–288).—Brief notes on 4 varieties of pears, 12 of apples, 5 of plums, 5 of raspberries, 3 of blackberries, 4 of currants, 1 of gooseberries, 6 of strawberries, 1 of mulberries, 12 of evergreen trees, and 37 of deciduous trees and shrubs.

Distribution of fruits and trees (pp. 289, 290).—A list of names and addresses of persons to whom Russian apple, willow, and poplar trees and grape-vines were sent in 1888.

Natural and artificial fertilization of plants (pp. 291–296), (illustrated).—The changes in plants by artificial fertilization under cultivation are illustrated by an account of the natural and artificial fertilization of strawberry plants.

Best climatic conditions for grapes, C. Poumeroulie (pp. 297–299).—This includes a tabular record of observations upon 25 varieties of American grapes made at the Station in 1887 and 1888. The table shows the time of leafing, the number of days from leafing to blooming, and from blooming to maturity, with the average temperature of each period and the aggregate heat for the entire season of growth. The number of days from leafing to ripening in 1887 varied from 114 for the Janesville variety to 147 for the Lady and Agawam.

REPORT OF ENTOMOLOGIST AND BOTANIST, OTTO LUGGER, PH. D. (pp. 300–394).—In the introduction it is stated that this report is for the last half of 1888. Besides this report, articles treating of entomological and botanical matters have been published in three bulletins issued by the Station, and numerous short articles in newspapers, in addition to a considerable correspondence. During the year 1888 the chinch-bug has been troublesome in the southern and central counties of the State, the army-worm in the northern counties, and the Rocky Mountain locust in Otter Tail County.

[Among other injurious insects active in that year were mentioned] the species of tent caterpillars (*Clisiocampa* sp.), canker-worms, gnats (*Simulium* sp.), the brown ptinus in mills (*Ptinus fur*), the American cimbex (*Cimbex americana*), the yellow-spotted willow-slug (*Nematus ventralis*), a thrips in clover, the maple-tree borer (*Ægeria acerni*), the raspberry cane-borer (*Agrilus ruficollis*).

Notes on the Rocky Mountain locust in Otter Tail County, Minnesota, in 1888 (pp. 305–349).—This includes an account of the breeding grounds of this locust, the history of its operations in Otter Tail County, an account of the means used to combat the locust, descriptions of the parasitic and other enemies of the locust, an estimate of the value of locusts as fertilizers, statements regarding the outlook for the year 1889, illustrated statements regarding the differences between the Rocky Mountain locust and other similar species, descriptions of the oviposition of the locust, and an appendix containing a letter by the entomologist to the Governor regarding the work of combating the locust, with suggestions as to a plan for future operations.

The Rocky Mountain locusts appeared in Minnesota in the village of Perham in the autumn of 1885. Owing to the lack of active measures to exterminate them they increased with such rapidity and caused such damage in different places in Otter Tail County that in 1888 the Governor of the State was appealed to for assistance against the pest. The entomologist of the Station was sent to the infested region and at once began preparations to combat the evil. Many of the farmers had become so discouraged that it was at first difficult to secure their co-operation. Large areas of unplowed fields scattered among the plowed and seeded ones afforded protection to large numbers of eggs, which hatched in due course of time. The behavior of the locust in 1887 was very different from that in 1888. In the former year the locust hatched (for the most part in timothy fields) early in May, and almost immediately commenced their destructive work.

The young locusts marched in large bodies to the nearest field, and entering, devoured every plant, so that in the course of a very short time the fields were as bare of vegetation as a well-trodden road. The insects went through their successive molts or stages with great regularity, and toward the middle of June nearly all the damage possible by the unfledged insects had already been inflicted. The year 1887 was also distinguished by a very dry summer, and cultivated plants showed but very little vitality, for as soon as the locusts attacked them they wilted and died at once. The winged insects kept moving from place to place, and did considerable damage. Nothing was secure, and they would eat with almost equal relish all kinds of plants. Even the few pine-trees planted in the yards of Perham were not alone denuded of their foliage, but the very bark was bitten off and devoured. Clothing of any kind left in garden or field was soon consumed by these omnivorous insects. They congregated in such immense numbers in some of the roads that people hesitated to drive their horses through these blinding swarms.

In 1888, owing to the severe winter and late spring, the eggs did not commence to hatch until early in June, and the young locusts remained in the neighborhood of their birthplace for a long time, traveled in small and irregular detachments, attacked only weaker plants of wheat, and were very irregular in passing through their successive stages of growth. This slow and irregular growth was thought to be due to the coolness and dampness of the season.

"Hopper-dozers" and similar machines were used, as suggested by Professor Riley in the First Annual Report of the United States Entomological Commission on the Rocky Mountain locust. Bounties were offered by the county commissioners at the rate of a dollar for each bushel of locusts caught. It is estimated that 35,000 bushels of locusts were killed in Otter Tail County. In general the observations made in 1888 indicated "that the locusts felt no longer at home in this region, were no longer healthy, and were greatly troubled by parasites." The parasitic enemies of the locust mentioned in the report are the red mite (*Trombidium locustarum*, Ril.), tachina flies, the common flesh fly (*Sarcophaga carnaria*, L.), bee-fly (*Systœchus oreas*), several species of blister beetles (*Macrobasis unicolor*, *Epicauta cinerea*, *E. pennsylvanica*, *E. vittata*, *E. trichrus*, *Cantharis nuttalli*), ground bettle (*Agonoderus pallipes*, Fab.), the larvæ of several species of *Harpalus* and *Amara*, the larvæ of *Calosoma frigidum*, Kirby, and of *Calosoma calidum*, Fab.; robber flies (*Asilidæ*), dragon flies (*Gomphus grasilinellus*, Walsh, *Cordulia spinigera*, Slys., *Libellulà exusta*, Say, *Leucorrhinia frigida*, Hagen, *Enalagma annexans*, Hagen, *Ischnura iners*, Hagen), hair snakes (*Gordius* and *Mermis*).

Among the birds observed to eat locusts were the black tern (*Hydrochelidon nigra surinamensis*). "The various species of blackbirds, such as the yellow-headed blackbird (*Xanthocephalus xanthocephalus*), the red-shouldered blackbird (*Agelaius phœniceus*), the rusty blackbird (*Scolecophagus carolinus*), the bronzed grackle (*Quiscalus quiscula aeneus*), the brewers' blackbird (*Scolecophagus cyanocephalus*), and the cow-bird (*Molothrus ater*)", owls, prairie-chickens, domesticated fowls, and a small shrew-mouse with a very pointed snout, evidently belonging to the insect eaters (*Insectivora*) was observed during the twilight to catch and eat locusts. Numerous toads, snakes, but chiefly turtles, were also fond of a dish of tender locusts.

Analyses of dried locusts made by the Station chemist, as well as two others quoted from European sources, show that these insects are particularly rich in nitrogen and contain a considerable amount of phosphoric acid. The specimens here analyzed gave in the dry (water-free) substance 10.7 per cent of nitrogen and 1.8 per cent of phosphoric acid.

It was observed that no locusts hatched in fields plowed during the fall and early spring. This is explained by a description of the method in which the eggs are deposited. The egg pod as left in the ground by the female points upward; the plow reverses the position of the egg pod and thus the young locusts when hatched are not able to reach the surface. It is urged that if the authorities of the State will compel the farmers to plow the infested fields the insects will be very largely exterminated.

Chinch bug (*Blissus leucopterus*, Say) (pp. 350–358), (illustrated).—An account of this insect with suggestions as to remedies.

The army-worm (*Leucania unipuncta*, Haw.) (pp. 359–368), (illustrated).—This insect was quite destructive in the northern part of the State in 1888. This article includes an account of observations made by the author in the vicinity of Henning, Otter Tail County, Minnesota, with popular descriptions of the insect in its various stages, and suggestions as to remedies. Among the parasitic enemies of the army-worm, a tachina fly (*Exorista leucaniæ*), *Apanteles* sp. (?), and *Ophion purgatum* were observed and bred by the author.

The inhabitants of our mouths (pp. 369–379), (illustrated).—An account of various micro-organisms found in the human mouth, with especial reference to the injury they cause to the teeth and may cause to health.

Fungi which kill insects (pp. 380–394), (illustrated).—This contains popular accounts of fungi which destroy insects, and statements regarding observations by the author on chinch-bugs killed by a fungus.

REPORT OF CHEMIST, D. N. HARPER, PH. D. (pp. 395–397).—This contains a description of the new chemical laboratory of the Station, completed the latter part of November, 1888, and a plan of its ground floor. Some work was begun in the laboratory of the university. Analyses of corn, sugar-beets, butter, etc., have been made, and the results will be published.

REPORT OF SUPERINTENDENT OF MINNETONKA FRUIT STATION, P. M. GIDEON (pp. 398–401).—A brief account of experiments by the author in the production of hardy varieties of apples by selection and cross-fertilization.

REPORT OF THE OWATONNA TREE STATION, E. H. S. DARTT (pp. 402–405).—This contains brief accounts of experiments with Russian apples, and of the experimental orchard, and a list of evergreen and deciduous trees growing at the Station.

ORCHARD PROTECTION, E. H. S. DARTT (pp. 406–408).—A paper read before the State Horticultural Society. It contains an argument for the planting of evergreen trees in orchards to protect the fruit-trees from winds and the heat of the sun.

NEW HAMPSHIRE.

New Hampshire Agricultural Experiment Station.

Department of New Hampshire College of Agriculture and the Mechanic Arts.
Location, Hanover. Director, G. H. Whitcher, B. S.

FIRST ANNUAL REPORT, 1888.

REPORT OF DIRECTOR (pp. 7–53).—The director for this Station was chosen February 22, 1888. Two months later a Board of Control was selected, and "defined plans formulated for the erection of the new experiment Station building for laboratory and offices." It was decided to make dairying a leading feature of the work of this Station. With this in view four average animals of each of the following breeds were obtained: Ayrshire, Holstein, Jersey, and Shorthorn. Among the problems to be studied are "the physical characteristics of the milk from these breeds; its chemical composition, and adaptability for butter making; and the economy of each breed as machines for converting fodder into milk and butter. At the same time the methods of handling milk by various systems of cold, deep setting, of shallow setting, and by the use of the centrifugal separator are being tested." Along with these will be pursued lines of experimenting which relate to the production of milk, such as the growing of crops, tests of varieties of forage plants, rotation of crops, use of fertilizers, the effects of late and early cutting upon the feeding value of hay, the compounding of rations, and the breeding and development of young cows with reference to their milking qualities. The diseases of plants, and injurious insects will also be studied. "Our work has been mainly in the line of determining the most profitable ration; not necessarily the one that produces the largest yield, but the one that produces milk and butter at the lowest price per quart or pound. * * * The various concentrated foods that are to be found in the market have been experimented with and their feeding values studied; the relative merits of ensilage and hay have been tested and the value of cured oats and rye investigated." The influence of food upon the per cent of fat in milk has also received considerable attention. The results of an experiment in fermenting bone with ashes is given in an appendix to the report.

> From the tabulated results it appears that this method is not a satisfactory one; for in all cases where ashes were used the whole of the soluble phosphoric acid was changed into either insoluble or reverted, while considerably over half of the "reverted" or citrate soluble phosphoric acid was made insoluble. This is a decided step in the wrong direction.

There is also a loss of nitrogen in the process. The need of methods of testing milk and cream at creameries, by which the amounts of fat in milk from different cows can be accurately determined, is strongly urged. It is shown that the prevailing custom at creameries of considering all milk of equal butter-making value is unjust. The mixed milk from some herds of cows will average 5 per cent of fat, while that from other herds will not average more than 3½ per cent. If, as is often the case, there is a variation of 4 or 5 per cent in the amount of fat in cream, there is a considerable difference in the money value of the cream. Regarding butter fat worth 20 cents per pound, 100 pounds of cream containing 19 per cent of fat would be worth $3.80, while if it contained 23½ per cent of fat it would be worth $4.70. A method of milk analysis worked out at this Station by C. L. Parsons, B. S., is given in an appendix to the report. This method does not involve the use of costly apparatus, and is applicable to skim-milk and buttermilk, as well as to whole milk.

During 1888 four bulletins were issued in editions of 10,000 copies. The mailing list of the Station numbers 7,000 addresses, and new names are being constantly received. The titles of the bulletins are as follows: No. 1, Ensilage; No. 2, Feeding Experiments; No. 3, When to Cut Corn for Ensilage; No. 4, Science and Practice of Stock Feeding. Abstracts of these bulletins are published in the report.

Bulletin No. 1. *Ensilage* (pp. 14-26).—The investigation reported in this bulletin was planned with reference to the needs of farmers of small or average means.

A few of the questions asked were: (1) Are costly silos of masonry necessary? (2) Can green crops be stored whole? (3) Is rapid filling necessary? (4) Is there any advantage to be gained by selecting the variety of corn planted?

(1) Experience demonstrates that a silo of 40 to 70 tons' capacity can be built in a section of almost any barn at a cost of $1 for each ton, or for $40 to $70. This pays for the lumber, the labor, and all materials used. On farms where there is an abundance of lumber and stone for foundations the cash outlay for a 100-ton silo need not exceed $25 for materials, saw bill, etc., and $10 for labor, supposing the team work is done by farm team, or $35 for a 100-ton silo. The first cost of a silo, then, need not deprive any farmer of the benefits of ensilage.

(2) The 2 years' experience on the college farm and elsewhere has shown that corn may be successfully stored in the silo without cutting, and the director advises those farmers who can not afford to purchase machinery for cutting to put the whole corn in the silo rather than go without ensilage.

(3) Slow filling is thought to be more economical and to produce better ensilage than rapid filling.

(4) The cost of producing an acre of ensilage from plowing to harvesting is calculated in detail and shown to be about $12; the cost of harvesting varied with the yield per acre and the method of harvesting. For ensilage cut in ¾-inch lengths the cost, including seed, cultivation, harvesting, and interest is reckoned as follows for different varieties:

Varieties.	Yield per acre.	Cost of harvesting per ton.	Total cost of ensilage per ton.
	Tons.		
Southern	20.45	$1.08	$2.21
Sanford	15.31	1.00	2.48
Northern Field	16.00	1.00	2.40
Pride of the North	12.54	1.24	3.07

Experience at the Station indicates that the cost of cutting was from 40 to 50 cents per ton of ensilage. In an experiment with different rates of seeding the thicker planting gave the larger yield, but the quality of the different products was not determined.

As regards the amount of ensilage needed in New Hampshire for one season's feeding, it is stated that, calculating for 50 pounds of ensilage per day for 200 days, 5 tons per animal would be needed, or 100 tons for 20 cattle. This would require a silo 15 by 15 feet and 30 feet deep, or 20 by 20 feet and 16 feet deep. The following method of constructing a comparatively cheap silo is recommended:

If economy is to be practiced, select a section or joint in the barn, remove floors, and if there is a barn cellar place sills on the bottom of this and set 2 by 8 scantling vertically, bringing the inside edges even with the sills of the barn. The bottom may or may not be cemented, according as the ground is wet or dry. If to be

> cemented, three casks of cement and an equal amount of sharp sand or gravel will cover a bottom 16 by 16 and turn up on the sides 2 feet, which will give a tight silo. Common spruce or hemlock boards, square-edged and planed on one side, are the best for boarding the inside of the silo; these are to be put on in two courses, breaking joints, and if thoroughly nailed will give a tight pit. No tonguing or matching is needed. Tar paper may be put between the boarding if desired, but I doubt if it is of great utility. At some point most easily accessible, an opening extending nearly the height of the silo must be made to put in the corn and take out the ensilage. The courses of boards should be cut shorter than the opening to allow loose boards to be set in, lapping on the door studding and making an air-tight joint. * * *
>
> A silo constructed as above outlined will cost from 50 cents to $1 for each ton of its capacity, according as all materials, including lumber and stone, are charged, or only labor, nails, rods, and cement.

For the raising of crops intended for the silo, "land that is near the silo is very desirable. * * * The land should be well manured with from ten to fifteen ox loads of good farm-yard manure, and in addition to this it will pay to apply 200 pounds of some concentrated fertilizer in or on the drills or hills." Two hundred and fifty pounds of dissolved bone-black, 200 pounds of muriate of potash, and 50 pounds of sulphate of ammonia make a desirable fertilizer in the region in which the Station is situated. Twelve to 16 tons of ensilage is considered an average yield per acre. The climate of each locality must determine what variety of corn is best for ensilage, but the author recommends the selection of a variety "which will, in average years, mature sufficiently to bring the kernel into the 'roasting stage.'" Sixteen quarts of seed corn are advised for the Northern and Sanford varieties. "Harvesting should commence in season to secure most of the crop before the first hard frost."

An experiment at the Station indicated that it was not necessary to weight the silo in order to have good ensilage, but, nevertheless, the weighting of small silos with muck or sand is advised, especially if they are not to be opened early in the winter. The use of silos enabled many farmers in New Hampshire to save their corn crop which had been touched by a severe frost early in September, 1888.

Bulletin No. 2.—Feeding experiment (pp. 26–28).—The bulletin contained the details of an experiment with 10 milch cows in 22 periods of a week each from December 6, 1887, to May 6, 1888. Silage, hay, dry corn fodder, bean vines, millet, mixed grain, buckwheat, gluten, and corn-and-cob meal were the feeding stuffs used.

In this report the results are stated in the following tables:

Summary of results of feeding experiment with milch cows.

Period.	Date.	Average daily yield of milk.											Total milk daily, herd.
		2	4	7	8	11	12	15	16*	17*	18*	19*	
		Qts.	*Qts.*	*Qts.*	*Qts.*	*Qts.*	*Qts.*	*Qts.*	*Qts.*	*Qts.*	*Qts.*	*Qts.*	*Qts.*
1	Dec. 6–11, 1887	13.75	......	16.21	18.37	14.12	15.75	13.58	16.58	9.04	12.75	16.75	229.20
2	Dec. 12–18	12.39	......	14.50	16.57	13.11	14.50	12.89	14.32	6.80	11.21	14.36	204.86
3	Dec. 19–25	12.75	......	14.75	16.61	13.39	14.61	12.86	13.53	6.32	11.71	13.71	205.57
4	Dec. 26 to Jan. 1, '88	12.64	......	15.36	17.18	14.14	15.07	12.86	14.14	7.21	12.25	14.00	212.00
5	Jan. 2–8	13.20	......	15.93	16.64	14.18	15.75	14.43	14.39	8.00	12.61	14.82	217.54
6	Jan. 9–13	14.05	......	17.10	17.45	15.70	17.20	14.75	15.10	8.55	14.05	11.05	231.45
7	Jan. 14-22	14.31	......	16.61	16.39	16.17	16.50	15.56	15.97	8.58	14.25	15.97	234.50
8	Jan. 23–29	13.21	......	15.25	14.75	15.39	13.30	13.10	14.50	7.40	12.80	14.32	206.18
9	Jan. 30 to Feb. 5	13.25	......	15.90	15.25	14.80	13.95	12.50	13.40	7.32	13.40	14.53	206.53
10	Feb. 6–12	13.10	......	13.80	15.39	15.60	13.20	12.30	13.80	7.53	13.40	14.75	207.00
11	Feb. 13–19	13.00	......	15.20	14.10	14.75	12.18	12.20	13.82	7.46	13.25	14.82	201.50
12	Feb. 20–26	12.46	22.00	14.75	14.60	14.25	11.70	12.10	12.60	7.60	12.60	14.00	200.00
13	Feb. 27 to Mar. 4	12.25	20.68	14.20	13.60	13.46	11.30	11.90	12.70	6.40	12.46	14.25	187.68
14	Mar. 5–11	12.06	21.02	14.96	14.68	13.90	10.96	11.80	12.40	6.40	12.30	14.00	189.19
15	Mar. 12–18	12.00	21.28	14.53	15.30	14.00	10.68	11.90	12.00	6.40	13.00	13.75	184.32
16	Mar. 19–25	10.50	19.21	11.70	11.40	12.20	7.20	10.20	9.43	4.90	10.90	10.60	144.22
17	Mar. 26 to April 1	11.35	18.78	13.10	13.60	12.60	7.00	11.20	10.75	6.70	12.00	12.60	163.40
18	Apr. 2–8	12.68	19.82	13.60	15.40	13.10	6.60	12.30	12.25	6.70	12.90	14.20	172.00
19	Apr. 9–15	13.10	20.00	13.90	15.80	14.30	8.20	14.00	12.60	6.80	13.90	15.40	181.00
20	Apr. 16–22	13.85	20.43	14.40	16.20	14.10	7.00	14.20	11.50	6.60	13.60	16.60	182.60
21	Apr. 23–29	14.71	21.21	13.80	17.40	14.70	......	13.70	10.60	6.40	13.20	14.70	200.70
22	Apr. 30 to May 6	......	21.07	13.60	18.80	14.40	......	......	......	......	......	......	......

* Heifers with first calves.

Period.	Date.	Cost of milk per quart.					Average pounds of milk to one pound of butter.
		To produce one pound butter.	Highest.	Lowest.	Average for ten cows.	Average for herd.	
		Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Pounds.*
1	December 6–11, 1887	23.70	2.69	1.32	1.655	2.02	25.25
2	December 12–18	27.45	3.58	1.47	1.864	2.27	25.90
3	December 19–25	28.13	5.09	1.94	2.473	2.98	24.46
4	December 26 to January 1, 1888	28.35	5.05	2.13	2.709	3.27	22.50
5	January 2–8	30.00	4.64	2.23	2.687	3.25	24.00
6	January 9–13	26.90	4.02	1.97	2.365	2.83	24.50
7	January 14–22	19.70	3.12	1.61	1.786	2.17	23.80
8	January 23–29	23.70	3.91	1.88	2.236	2.58	22.80
9	January 30 to February 5	27.30	3.95	1.82	2.15	2.56	24.10
10	February 6–12	24.10	3.84	1.83	2.15	2.57	24.13
11	February 13–19	22.30	3.92	1.91	2.21	2.64	21.70
12	February 20–26	24.90	3.80	1.31	2.28	2.39	23.50
13	February 27 to March 4	24.80	4.53	1.40	2.36	2.54	22.60
14	March 5–11	25.80	4.53	1.38	2.34	2.53	23.70
15	March 12–18	25.80	4.53	1.36	2.34	2.58	23.60
16	March 19–25	23.40	4.73	1.20	2.28	2.79	22.10
17	March 26 to April 1	27.60	4.32	1.54	2.60	2.90	22.80
18	April 2–8	34.90	5.70	1.90	3.18	3.66	23.60
19	April 9–15	29.40	5.00	1.72	2.66	3.25	23.70
20	April 16–22	....	....	....	....	....	23.60
21	April 23–29	....	....	....	....	....	24.10

Summary of results of feeding experiment with milch cows—Continued.

Period.	Date.	Daily ration.												Cost of daily ration per head.
		Ensilage.			Dry fodder.					Grain.				
		Sanford corn.	Southern corn.	Northern corn.	Mixed hay (largely clover).	Herd's-grass hay.	Corn fodder.	Bean vines.	Millet.	Mixed grain.	Buckwheat.	Gluten.	Corn-and-cob meal.	
		Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Cts.*
1	December 6-11, 1887	50	....	....	5	....	....	5	....	1¼	....	....	....	11⅓
2	December 12-18	....	50	....	5	....	....	5	....	1¼	....	....	....	11⅓
3	December 19-25	..	50	....	5	....	....	5	....	4	....	....	....	15
4	December 26 to January 1, 1888	....	50	....	5	....	....	5	....	4	2	....	....	17
5	January 2-8	....	50	....	5	....	6	....	....	4	2	....	....	17⅓
6	January 9-13	....	50	....	5	....	6	....	....	....	....	3	2	16
7	January 14-22	....	....	50	5	....	6	....	....	....	....	¾	½	12½
8	January 23-29	....	....	50	5	....	6	....	....	2	....	....	....	13½
9	January 30 to February 5	....	....	50	5	....	....	....	6	2	....	....	....	13½
10	February 6-12	....	....	50	5	....	....	....	6	2	....	....	....	13
11	February 13-19	....	....	50	5	....	....	....	6	2	....	....	....	13½
12	February 20-26	....	....	50	5	....	....	....	6	2	....	....	....	13½
13	February 27 to March 4	....	....	50	5	....	....	....	6	2	....	....	....	13½
14	March 5-11	....	....	50	5	....	....	....	6	2	....	....	....	13½
15	March 12-18	....	....	50	5	....	....	....	6	2	....	....	....	13½
16	March 19-25	....	....	....	5	*10½	....	....	6	2	....	....	....	10½
17	March 26 to April 1	....	....	50	5	....	....	....	6	2	....	....	....	13¾
18	April 2-8	....	....	....	5	....	8	....	6	9½	....	....	....	17½
19	April 9-15	....	....	....	5	....	8	....	6	8	....	....	....	16¾
20	April 16-22	....	....	....	....	....	....	....	....	....	....	....	....	....
21	April 23-29	....	....	....	....	....	....	....	....	....	....	....	....	....

* Cows were fed all the hay they would eat and weight noted.

Taking all the results as they stand, our ten cows produced milk at the following average prices:

Cost per quart of milk from ten cows.

Food.	Whole herd.	Ten cows.	Best cow.*	Poorest cow.
	Cents.	*Cents.*	*Cents.*	*Cents.*
Sanford	2.02	1.65	1.32	2.69
Southern corn	2.92	2.44	1.95	4.49
Northern corn	2.54	2.24	1.66	4.04
Hay	2.79	2.28	1.20	4.73
Corn fodder	3.45	2.92	1.81	5.35

* After the 13th period a new cow, No. 4, came in, and this reduced the individual cost of milk produced for "best cow."

Bulletin No. 3.—*Corn for ensilage* (pp. 28, 29).—This is a summary of analyses made to get light upon the relative amounts of nutrients in corn at different stages of its growth, and the time when the crop contains the most nutriment per acre.

In all the varieties there was a great falling off in the rate of increase immediately after the tassels were put forth, the plant evidently accumulating dry substance much more rapidly while the tassels were being developed than at any subsequent period.

Summary of analyses of corn for ensilage.

Variety of corn.	Plants per acre.	Weight per stalk.				Computed weight per acre.			
		July 26.	Aug. 5.	Aug. 19.	Sept. 16.	July 26.	Aug. 5.	Aug. 19.	Sept. 16.
		Ounces.	*Ounces.*	*Ounces.*	*Ounces.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
Southern	13,980	15	37.4	56	47	13,106	32,678	48,875	41,066
Sanford	17,750	9.6	26.8	36	27.6	10,625	29,688	39,937	30,618
Pride of the North	14,433	12	30	39.6	27.8	10,824	27,061	35,721	25,077
Northern field (flint)	22,857	12.2	24.8	24.6	22.4	17,428	35,428	35,142	32,000

Actual amount of water, dry substance, and the separate constituents of the dry substance per acre, for each variety of corn at each of the four dates at which samples were taken.

(*These are in pounds per acre.*)

Variety of corn.	Date.	Water.	Dry substance.	Albuminoids.	Ether extract.	Fiber.	Nitrogen-free extract.	Ash.	Phosphoric acid.	Potash.
Southern	July 26, 1887	11,959	1,147	209.7	44.5	262	523	103.5	1.6	5.5
Sanford	...do	9,653	972	151	65	218	458	80	2.8	6.4
Pride of the North	...do	9,812	1,012	176	48	247	433	107	6.7	9.6
Northern field (flint)	...do	15,293	2,135	312	143	521	972	186	6.4	6.0
Southern	Aug. 5, 1887	29,142	3,536	496.7	166.6	996.6	1,572	304	9.8	20.0
Sanford	...do	25,769	3,919	484	216	908	2,042	267	17.0	12.0
Pride of the North	...do	23,695	3,366	533	151	906	1,501	276	15.0	24.0
Northern field (flint)	...do	30,503	4,925	665	219	1,150	2,660	232	13.8	10.3
Southern	Aug. 19, 1887	41,542	7,333	1,098	366	1,905	3,474	490	13.4	28.0
Sanford	...do	34,645	5,292	595	227	1,309	2,903	292	27.0	13.0
Pride of the North	...do	29,381	6,340	686	240	1,419	3,669	322	24 6	14.3
Northern field (flint)	...do	28,623	6,519	664	208	1,603	3,684	359	14.0	19.0
Southern	Sept. 16, 1887	30,964	10,102	969	238	2,443	5,987	464	11.0	37.6
Sanford	...do	23,637	6,980	646	331	1,473	4,241	285	......	.....
Pride of the North	...do	17,667	7,410	815	399	1,514	4,238	444	22.3	8.6
Northern field (flint)	...do	23,168	8,832	848	416	1,533	5,404	541	......	.....

In conclusion we may say that, all things considered, it is best to plant such varieties as will, in a given locality, produce plants having well-filled ears, the kernels being in the milk, or, better still, in the "doughy" state, and to delay the harvesting until the plant shows evident signs of ripening, such as the turning of the lower leaves, the glazing of the kernel in the flint, or the shriveling of the dent varieties. Up to this point there is a gain in two ways: first, an actual gain in the dry matter; and, second, a loss of water, reducing the ratio between the water and dry substance to about that required by cattle, thus improving the ensilage and reducing the labor in handling.

Bulletin No. 4.—*Stock feeding* (pp. 29–53).—This contains explanations of technical terms used in stating the results of analyses of feeding stuffs; illustrations of such analyses; statements regarding "the uses of food in the animal system;" tables of feeding standards from German and American sources, with explanations of their use; and tables showing 25 different rations calculated for the conditions in New Hampshire for milch cows, fattening cattle, working oxen, and horses at heavy and light work.

THOROUGHNESS OF CHURNING AS AFFECTED BY TEMPERATURE AND RIPENESS OF CREAM, A. H. WOOD, B. S. (pp. 54–64).—"In practice it is impossible to recover all of the fat contained in the milk; a part is lost in the skim-milk, and a portion of that removed in the cream escapes in the buttermilk, but the variation in the amount recovered may make all the difference between a paying and a losing business. * * * There are probably but few dairies or creameries where less than 10 per cent [of the fat contained in the milk] is lost, and in some private dairies the loss may reach as high as 30 or 35 per cent. It would not be overstating the case to say of the cows devoted to butter production in New England, that of every 100 pounds of butter fat they produce 15 pounds are lost in the process of manufacture. Evidently a a reduction in either line of loss would be a direct gain to the farmer, and there is plainly room for quite a material reduction."

Fat in buttermilk.—In analyses of about 60 samples of buttermilk (other than those reported further on) derived from milk of the four breeds (Ayrshire, Holstein, Jersey, and Durhams) at this Station under different conditions of raising and treating the cream, some being from nearly sweet and other from very sour creams, the variation in percentage of fat was from 0.26 to 3.43, and the average 1.25 per cent.

Influence of temperature on thoroughness of churning.—Three trials were made, in which cream which had been separated by means of the De Laval "hand separator" was churned, one part at 60° and the other at 64° Fah. In two cases the cream was sour and in one nearly sweet. The amount of butter separated in churning was in each case slightly larger at 60°.

Churning sweet cream.—Trials were made to test the practicability of churning sweet cream, "assuming that temperature must be the chief factor in determining the thoroughness with which perfectly sweet cream from any given source can be churned," and "taking the amount of fat remaining in the buttermilk as the measure of efficiency of churning." The mixed milk of the entire Station herd, which consists about equally of Jerseys, Holsteins, Ayrshires, and Durhams, was used. "A few of the cows were fresh in milk, some were nearly dry, and others were in the intermediate stages. Their food consisted of hay, rye hay, cured oats, ensilage, corn meal, gluten, cotton seed, shorts, and middlings, there being at any time not less than eight distinct combinations of these fodders in the feeding of cows from which the milk was taken."

The night's milk was set away in a cool room, mixed in the morning with the morning's milk, and cream separated in the entire lot at once. As soon as the cream had cooled it was churned in a Stoddard churn. Different temperatures were used for the churning.

Summary of experiment in churning sweet cream.

No. of test.	Milk.	Cream.	Temperature of cream when churned.	Speed of churning, revolutions per minute.	Time of churning.	Buttermilk.	Fat in buttermilk.	Fat lost in buttermilk per 100 pounds of milk.
	Pounds.	*Pounds.*	° *Fah.*		*Minutes.*	*Pounds.*	*Per cent.*	*Pounds.*
1	221.00	28.00	66	65	10	19.81	9.58	.860
2*	19.00	....	60	70	20	16.87	2.86	....
3	194.00	25.75	61	70	20	18.62	6.50	.620
4	225.00	28.00	58	65	34	18.25	2.79	.230
5	189.25	21.75	54	65	23	14.87	1.15	.090
6	224.75	29.50	50-54	65	33	19.50	1.01	.090
7	129.25	16.75	46–54	70	50	11.00	.59	.050
8	214 50	27.25	44–50	75	60	18.06	.40	.030
9	198.25	26.25	45–48	80	57	17.50	.26	.025
10	203.00	25.75	61	65	20	17.31	6.17	.530
11	210.00	27.75	43–47	75	70	17.87	.46	.040
12	368.00	45.75	44–58	70	140	31.00	.36	.030
13	375.00	51.50	46–51	65	145	34.50	.41	.038
14	600.00	74.50	48–57	75	120	47.00	.50	.039
15	425.75	55.75	50–55	70	50	36.50	.52	.045
16	397.50	51.25	48–58	65	150	34.00	.69	.058
17	203.00	38.50	44–58	80	125	28.25	.44	.061
18	297.00	62.00	49–61	70	215	46.00	.47	.073
19	98.00	22.50	51–59	70	80	17.62	.53	.095
20	55.44	6.56	53–61	65	75	4.62	.53	.044

* Buttermilk from No. 1 rechurned.

"Taken as a whole, I think that the table demonstrates the possibility of thoroughly churning sweet cream."

Sweet vs. sour cream.—In sixteen trials the cream from four milkings, which had been kept in ice water, was mixed and divided, one part being churned immediately and the other allowed to become sour and somewhat thick before churning. The following table gives the results of the trial:

No. of test.	Condition of cream.	Milk.	Cream.	Temperature of cream when churned.	Speed of churn, revolutions per minute.	Time of churning.	Buttermilk.	Fat in butter milk.	Fat lost in buttermilk per 100 pounds of milk.
		Pounds.	*Pounds.*	° *Fah.*		*Minutes.*	*Pounds.*	*Per ct.*	*Pounds.*
1	Sweet	203.25	25.25	54–57	65	32	16.00	.81	.064
2	Sour and thick	203.25	25.25	54–56	65	13	16.00	.26	.021
3	Sweet	204.75	28.75	43–50	80	80	19.25	.55	.052
4	Sour and thick	304.75	28.75	43–50	80	75	19.25	.46	.043
5	Sweet	220.00	29.50	50–54	75	55	20.25	.35	.032
6	Sour	220.00	29.50	50–55	75	50	20.25	.48	.044
7	Sweet	205.50	27.50	50–55	70	80	18.25	.55	.048
8	Sour	218.75	32.25	50–55	70	53	22.50	.49	.050
9	Sour	312.75	41.50	50–57	65	70	29.00	.56	.052
10	Sour	312.75	41.50	56–60	65	47	29.00	.72	.067
11	Sweet	264.00	32.75	60	65	55	19.00	1.46	.105
12	Sweet	264.00	32.75	64	65	40	19.00	2.76	.213
13	Sweet	323.50	38.50	64	60	34	26.00	1.75	.140
14	Sour	323.50	38.50	64	60	38	26.00	1.59	.129
15	Sweet	64.00	17.00	65	60	10	13.00	.76	.154
16	Sour	64.00	17.00	65	60	16	13.00	.64	.130

If it is safe to draw any conclusion from so few tests, it would be that at a temperature of 50° to 55° there is not any practical difference in the thoroughness with which sweet and sour cream may be churned. * * *

Further work may develop contradictory evidence, but thus far, in all cases where comparisons could fairly be made, the indications have been that temperature has an important bearing upon the thoroughness with which any cream may be churned; that sweet cream may be churned and nearly if not quite the maximum amount of butter obtained if the churning be done at a temperature of about 50°.

Quality of sweet-cream butter.—There are three principal ways in which the quality of butter may be affected—its grain, or, as we might say, its mechanical condition; its flavor; and its keeping qualities. In my experience the sweet-cream butter excelled in grain. * * *

The keeping qualities of butter are generally held to depend chiefly upon the amount of casein or albuminoid matter that it contains, and the only evidence we can present in this direction at present are a few analyses of sweet and sour-cream butter in which the per cent of curd has been determined.

Analysis of butter.

	Condition of cream.	Per cent of water.	Per cent of fat.	Per cent of casein.
1	Sweet	10.21	87.75	.19
2	Sour and thick	12.19	82.74	.43
3	Sweet	11.34	82.68	.51
4	Sour and thick	10.15	84.19	.69
5	Sweet	11.81	84.59	.37
6	Sour	12.21	80.91	.60
	Average in sweet-cream butter			.36
	Average in sour-cream butter			.57
	Average in 19 samples exhibited at dairymen's meeting, January, 1889			.68

FERMENTING BONE WITH ASHES, LIME, ETC., E. H. FARRINGTON, M. S. (pp. 65–68).—Trials were made to study the effect on the soluble, reverted, and insoluble phosphoric acid of bones, of composting with ashes, quicklime, and caustic potash solution.

The following mixtures were put up in two-quart jars, covered, and kept in a vacant room at from 60° to 80° Fah. for from 2 to 3 weeks:

A. Ground bone, 305.3 grams; ashes, 305.3 grams; quicklime, 45.8 grams; water, 343.5 grams.

B. Ground bone, 500 grams; ashes, 500 grams; water, 500 grams.

C. Ground bone, 300 grams; ashes, 500 grams; water, 500 grams.

D. Ground bone, 500 grams; 10 per cent solution of caustic potash (KOH), 200 grams.

E. Ground bone, 250 grams; quicklime, 500 grams; water enough to slake lime and keep mixture moist.

F. Ground bone, 400 grams; water, 300 grams.

G. Ground bone, 60 grams; ashes, 100 grams; water, 100 grams. The same proportion as in C. This was thoroughly mixed and then dried down the same day for analysis before any fermentation took place.

From the analyses of the ground bone and ashes used, and the mixtures after fermentation, the following table is made:

	Phosphoric acid.				Nitrogen.	Effect of fermentation.	
	Soluble.	Reverted.	Insoluble.	Available.		Soluble made reverted by fermentation.	Reverted made insoluble by fermentation.
						Per cent.	*Per cent.*
Original amount in A	6.47	37.78	28.08	44.25	10.32	....	....
Found after fermentation, A	None	14.65	57.40	14.65	10.08	100	67.0
Original amount in B	10.60	61.85	46.00	72.45	16.90	....	....
Found after fermentation, B	None	37.12	80.84	37.12	16.88	100	48.7
Original amount in C	6.36	37.11	27.60	43.47	10.14	....	....
Found after fermentation, C	None	18.36	55.76	18.36	9.88	100	64.7
Original amount in D	10.60	56.50	40.65	67.10	16.90	....	....
Found after fermentation, D	2.07	47.83	58.75	49.90	16.32	80	27.0
Original amount in E	5.30	28.25	20.32	33.55	8.45	....	....
Found after fermentation, E	None	8.44	46.03	8.44	7.56	100	75.0
Original amount in F	8.48	45.20	32.52	53.68	....	....	....
Found after fermentation, F	4.82	41.56	39.21	46.48	....	43	13.0
Original amount in G	1.27	7.87	5.94	9.14	....	....	....
Found after fermentation, G	None	5.48	9.42	5.48	....	100	40.0

A NEW VOLUMETRIC METHOD FOR THE ESTIMATION OF FAT IN MILK, SKIM-MILK, BUTTERMILK, AND CREAM, C. L. PARSONS, B. S. (pp. 69–83).—The method depends upon dissolving out the fat by shaking the sample at ordinary temperature with caustic soda solution, alcoholic soap solution, and pure gasoline, evaporating the gasoline from a measured portion after it has risen in a clear layer at the top of the solution, and measuring the fat remaining.

Apparatus and solutions required.—The apparatus necessary are: three pipettes of 100, 50, and 25 c. c. capacity, respectively; a measuring cylinder holding 10 c. c.; a long, narrow, graduated tube of about 4 c. c. capacity for measuring the fat; one or more bottles about 11 inches high and 1½ inches in diameter (holding about 250 c. c.), used for shaking the milk with the solutions; one or more flasks of about 70 c. c. capacity with a short neck, which should fit into the measuring tube, cut off obliquely, used for evaporating the gasoline from an aliquot part of the solution of fat; and some sort of drying oven.

The solutions recommended are: pure gasoline (86°, 88°, or 90°), leaving no residue on evaporation; caustic soda solution (one part sodium hydrate to two parts of water); alcoholic soap solution made by dissolving one ounce of castile soap in one gallon of 95 per cent alcohol; and strong acetic acid.

Directions for analysis.—Mix in the bottle 100 c. c. of the milk, 10 c. c. of the caustic soda solution, 5 c. c. of alcoholic soap solution, and 50 c. c. of gasoline. Cork the bottle and “shake hard for a few seconds, and again five or six times, at about equal intervals, in the next half hour. After the last shaking let the bottle stand a few minutes to see if the gasoline will not rise to the top. If it does not add 5 c. c. of alcoholic soap solution again, and as soon as bubbles cease to rise turn the bottles slowly upside down and back again." As soon as the solution of fat in the gasoline has separated sufficiently 25 c. c. are to be measured out into one of the flasks, and the gasoline evaporated by holding the flask in hot water. "Add two drops of acetic acid to the fat which is left behind. Place the flask in the oven and dry it at 245° to 255° Fah. for one hour and a half. Now turn the fat slowly into one of the measuring tubes previously placed in the oven. Let the flask drip for ten minutes while the oven is at the same temperature. Cool the measuring tube until the first appearance of the fat solidifying; hold clasped in the hand a moment, and then read off the number on the scale which corresponds with the upper surface of the fat," and calculate the per cent by a table.

Skim-milk and buttermilk are treated in exactly the same manner, with the exception that if they contain less than one per cent of fat the drying need not be prolonged beyond three-quarters of an hour, and the measuring tubes should be partly filled with dried fat before adding that from the analysis; the difference in the readings before and after adding will give the reading required.

In testing cream, 100 c. c. are to be diluted with an equal quantity of water, well mixed, and 50 c. c. of the mixture taken for the analysis.

Of 64 analyses of whole milk by this new method, part of which were made by Mr. Parsons himself and part by persons unaccustomed to chemical work, the greatest difference from the gravimetric determinations was 0.19 per cent, and in only four cases was the difference as much as 0.15 per cent; of 17 tests of cream, the results of 5 differed from the gravimetric by 0.2 or over, the largest error being 0.52 per cent; and of 13 tests of skim-milk and buttermilk the error was in no case as high as 0.15 per cent. Of 32 trials, in which the results of tests of whole, skim, and buttermilks by this new method were compared with those of the Soxhlet method, the difference between the two was in one case as large as 0.2 per cent.

Tables to be used in calculating the results.—The following tables are taken from the report. Their use is thus explained: "Find the first two figures of the reading obtained from the scale in the left-hand column headed c. c. Then pass horizontally towards the right to the column which has the third figure of the reading for its heading, and the per cent of fat corresponding to the reading of the scale is found."

For whole milk, skim-milk, and buttermilk containing from .18 *to* 8.56 *per cent of fat.*

c. c.	0	1	2	3	4	5	6	7	8	9
0.1	.18	.20	.22	.24	.26	.27	.29	.31	.33	.35
0.2	.36	.38	.40	.42	.44	.45	.47	.49	.51	.53
0.3	.54	.56	.58	.60	.62	.63	.65	.67	.69	.71
0.4	.72	.74	.76	.78	.80	.81	.83	.85	.87	.89
0.5	.90	.92	.94	.96	.98	1.00	1.02	1.04	1.06	1.08
0.6	1.09	1.11	1.13	1.15	1.17	1.18	1.20	1.22	1.24	1.26
0.7	1.28	1.30	1.32	1.34	1.36	1.37	1.39	1.41	1.43	1.45
0.8	1.46	1.48	1.50	1.52	1.54	1.56	1.58	1.60	1.62	1.64
0.9	1.65	1.67	1.69	1.71	1.73	1.75	1.77	1.79	1.81	1.83
1.0	1.85	1.87	1.89	1.91	1.93	1.94	1.96	1.98	2.00	2.02
1.1	2.04	2.06	2.08	2.10	2.12	2.13	2.15	2.17	2.19	2.21
1.2	2.23	2.25	2.27	2.29	2.31	2.33	2.35	2.37	2.39	2.41
1.3	2.43	2.45	2.47	2.49	2.51	2.53	2.55	2.57	2.59	2.61
1.4	2.63	2.65	2.67	2.69	2.71	2.73	2.75	2.77	2.79	2.81
1.5	2.83	2.85	2.87	2.89	2.91	2.93	2.95	2.97	2.99	3.01
1.6	3.03	3.05	3.07	3.09	3.11	3.13	3.15	3.17	3.19	3.21
1.7	3.23	3.25	3.27	3.29	3.31	3.33	3.36	3.38	3.40	3.42
1.8	3.44	3.46	3.48	3.50	3.52	3.54	3.56	3.58	3.60	3,62
1.9	3.64	3.66	3.68	3.70	3.72	3.75	3.77	3.79	3.81	3.83
2.0	3.85	3.87	3.89	3.91	3.93	3.96	3.98	4.00	4.02	4.04
2.1	4.06	4.08	4.10	4.12	4.14	4.17	4.19	4.21	4.23	4.25
2.2	4.27	4.29	4.31	4.33	4.35	4.38	4.40	4.42	4.44	4.46
2.3	4.48	4.50	4.52	4.55	4.57	4.59	4.61	4.64	4.66	4.68
2.4	4.70	4.72	4.74	4.77	4.79	4.81	4.83	4.86	4.88	4.90
2.5	4.92	4.94	4.96	4.99	5.01	5.03	5.05	5.08	5.10	5.12
2.6	5.14	5.16	5.18	5.21	5.23	5.25	5.27	5.30	5.32	5,34
2.7	5.36	5.39	5.41	5.43	5.45	5.47	5.49	5.52	5.54	5.56
2.8	5.59	5.61	5.63	5.66	5.68	5.70	5.72	5.74	5.77	5.79
2.9	5.81	5.83	5.85	5.88	5.90	5.92	5.94	5.97	5.99	6.01
3.0	6.04	6.06	6.08	6.11	6.13	6.15	6.17	6.20	6.22	6.24
3.1	6.27	6.29	6.31	6.34	6.36	6.38	6.40	6.43	6.45	6.47
3.2	6.50	6.52	6.54	6.57	6.59	6.62	6.64	6.66	6.68	6.70
3.3	6.73	6.75	6.77	6.80	6.82	6.85	6.87	6.89	6.92	6.94
3.4	6.97	6.99	7.01	7.04	7.07	7.09	7.12	7.14	7.16	7.18
3.5	7.20	7.22	7.25	7.28	7.31	7.33	7.35	7.38	7.41	7.43
3.6	7.45	7.47	7.49	7.52	7.54	7.57	7.59	7.61	7.64	7.66
3.7	7.69	7.71	7.74	7.76	7.79	7.81	7.83	7.86	7.88	7.91
3.8	7.94	7.96	7.99	8.01	8.03	8.06	8.08	8.11	8.14	8.17
3.9	8.19	8.22	8.25	8.27	8.29	8.31	8.34	8.36	8.38	8.41
4.0	8.43	8.46	8.48	8.51	8.53	8.56	....	....	....	....

For cream, containing from 15 *to* 45.6 *per cent of fat.*

c. c.	0	1	2	3	4	5	6	7	8	9
1.9	15.01	15.09	15.18	15.27	15.35	15.43	15.52	15.60	15.69	15.77
2.0	15.86	15.94	16.03	16.11	16.20	16.29	16.37	16.47	16.55	16.64
2.1	16.73	16.81	16.90	16.99	17.08	17.16	17.25	17.34	17.43	17.52
2.2	17.60	17.69	17.78	17.87	17.95	18.04	18.13	18.22	18.31	18.40
2.3	18.48	18.57	18.66	18.75	18.84	18.93	19.01	19.10	19.19	19.29
2.4	19.37	19.46	19.55	19.64	19.73	19.82	19.91	20.00	20.09	20.17
2.5	20.26	20.35	20.45	20.54	20.63	20.72	20.81	20.90	20.99	21.08
2.6	21.17	21.26	21.36	21.45	21.54	21.63	21.72	21.81	21.90	22.00
2.7	22.09	22.18	22.27	22.36	22.45	22.54	22.64	22.73	22.82	22.92
2.8	23.01	23.10	23.20	23.29	23.38	23.47	23.56	23.66	23.75	23.85
2.9	23.94	24.03	24.13	24.22	24.31	24.41	24.50	24.60	24.69	24.79
3.0	24.88	24.98	25.07	25.17	25.26	25.35	25.45	25.54	25.64	25.73
3.1	25.83	25.92	26.01	26.10	26.20	26.29	26.39	26.49	26.59	26.68
3.2	26.77	26.87	26.97	27.07	27.17	27.26	27.36	27.46	27.55	27.65
3.3	27.74	27.84	27.94	28.04	28.13	28.23	28.33	28.42	28.52	28.62
3.4	28.72	28.81	28.91	29.00	29.10	29.20	29.30	29.40	29.50	29.60
3.5	29.70	29.80	29.90	30.00	30.10	30.19	30.29	30.39	30.49	30.59
3.6	30.69	30.79	30.89	30.99	31.09	31.19	31.29	31.39	31.49	31.59
3.7	31.69	31.79	31.89	31.99	32.10	32.20	32.30	32.40	32.50	32.60
3.8	32.71	32.81	32.91	33.01	33.11	33.21	33.31	33.41	33.51	33.61
3.9	33.72	33.82	33.93	34.03	34.13	34.24	34.35	34.45	34.55	34.65
4.0	34.75	34.85	34.96	35.06	35.16	35.27	35.38	35.48	35.59	35.69
4.1	35.80	35.91	36.01	36.11	36.21	36.31	36.41	36.52	36.62	36.73
4.2	36.83	36.94	37.04	37.15	37.25	37.36	37.47	37.57	37.68	37.78
4.3	37.89	38.00	38.10	38.21	38.31	38.42	38.53	38.64	38.74	38.85
4.4	38.96	39.07	39.18	39.28	39.39	39.50	39.61	39.71	39.82	39.93
4.5	40.04	40.15	40.26	40.37	40.48	40.59	40.70	40.81	40.92	41.03
4.6	41.14	41.25	41.36	41.47	41.58	41.69	41.80	41.91	42.02	42.13
4.7	42.24	42.35	42.46	42.57	42.68	42.79	42.90	43.01	43.12	43.23
4.8	43.34	43.45	43.57	43.68	43.79	43.90	44.02	44.13	44.25	44.36
4.9	44.47	44.59	44.70	44.82	44.93	45.94	45.15	45.27	45.38	45.59
5.0	45.60	....	....	....	....	....	....	....	....	....

SIZE OF FAT GLOBULES OF MILK, H. H. LAMSON, M. D. (pp. 84–88).—The following summarizes the observations made at this Station on the size of fat globules in the milk of different breeds:

> The globules of milk vary greatly in size, ranging from as small as $\frac{1}{40000}$ of an inch in diameter to $\frac{1}{2500}$ of an inch, and in a few instances observed even larger. The average in the measurements tabulated here is about $\frac{1}{8000}$. The variation in different breeds is well marked. In Jersey milk the globules are large and tolerably even in size, the average being $\frac{1}{6230}$. The globules of Holstein milk are smaller and less regular, the average being $\frac{1}{9214}$. Between these two extremes lie the Durham, averaging $\frac{1}{8110}$, and the Ayrshire, $\frac{1}{8382}$.
>
> In the following table the fractions represent averages, the globules classed under them varying slightly on either side:

	Diameter.						
	$\frac{1}{20000}$	$\frac{1}{10000}$	$\frac{1}{6600}$	$\frac{1}{5000}$	$\frac{1}{4000}$	$\frac{1}{3300}$	$\frac{1}{2850}$
	Per cent	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Jersey	9.04	20.30	30.15	24.32	13.15	.85	.05
Holstein	31.24	38 04	20.35	8.32	1.84	.21	....
Ayrshire	23.32	35.45	24.98	12.43	3.65	.27	....
Durham	22.71	34.33	24.21	12.22	5.45	1.08	....

MISCELLANEOUS ANALYSES (pp. 89–93).—Analyses are given of ash of milk, "solid matter collected on inside of centrifugal separator bowl," samples of water taken from ditches on manured and unmanured plats, four commercial fertilizers, "Flora Vita," Canada wood ashes, and "waste lime from a tannery."

Ash in milk.—Composition of 100 parts of ash:

Potash (K_2O)	27.83
Phosphoric acid (P_2O_5)	25.34
Soda (Na_2O)	8.65
Lime (CaO)	21.05
Magnesia (MgO)	1.67
Iron oxide	Trace.
Chlorine	14.83
Carbon	1.31
Undetermined	.76
	103.34
Less oxygen equal to chlorine	3.34
	100.00

Taking the average percentage of ash in milk at 0.75 (the average of over 1,000 determinations made at this Station), and the percentage of nitrogen at 0.48, the following estimate is made of the amounts of valuable fertilizing ingredients contained in 1,000 pounds (464 quarts) of milk:

	Pounds.
Total ash	7.50
Potash	2.09
Phosphoric acid	1.90
Nitrogen	4.80

OHIO.

Ohio Agricultural Experiment Station.

Location, Columbus. Director, Charles E. Thorne.

SEVENTH ANNUAL REPORT, 1888.

REPORT OF DIRECTOR (pp. 7–19).—Delays incident to a reorganization under the act of Congress of March 2, 1887, are stated to have temporarily embarrassed the Station in its operations, so that this report of the first season's operations under the national law relates very largely to preparatory work. The transfer to the new management took place April 1, 1888. More room being needed by the Station under its new conditions—

A brick building 39 by 45 feet in size, with a basement, two stories, and an attic, has been erected and finished so far as funds procurable would permit. The basement contains a room for heating apparatus; one for a potting room for a greenhouse, which it is proposed to attach to the main building; and two rooms for cellar storage. The first floor is divided into six small offices for the use of the Station officers. The second floor contains two more offices, a library, a chemical and a veterinary laboratory, and the third or attic floor is designed for a museum. It is proposed to attach to this two greenhouses, one 96, the other 112 feet long, with a seed room 16 by 20. One end of one of the greenhouses is to be used as an insectary.

As regards experimental investigations, provision was first made for the continuation of the work previously carried on, especially field experiments, which must necessarily be repeated many successive seasons to reach established conclusions.

Attention was next given to the extension of certain lines of the Station's work into wider fields. The most important step in this direction is the preparation for a systematic study of soil fertility; this being, in our judgment, one of the most important problems towards the elucidation of which the energies and resources of our Station can be directed. Investigations on this problem have been continuously carried on here since the first organization of the Station; but with the limited resources in land and money heretofore at command of the Station, it has been impossible to so conduct this work as to obtain satisfactory results. * * *

For this reason it has been decided to abandon the plat of land where this work has hitherto been conducted, and a field of very uniform soil lying in another part of the farm, has been thoroughly drained and divided into five sections, one each being designed for the continuous cultivation of corn, oats, wheat, and potatoes, both without any manure or fertilizer and with manures of various kinds, and one for the culture of the cereal crops in rotation with grass and clover.

A diagram shows the arrangement of three of these sections, each section being divided into twenty-two lots 16 feet wide by 272½ feet long, and separated from each other by spaces 2 feet wide. Underdrains are laid under alternate divisions between the plats, so that each plat has a drain on one side or the other. It will be noted that every third plat is to be left without any fertilizer, thus leaving an unfertilized plat on one side or the other of every fertilized plat. On these plats those elements of a fertilizer which experience has shown to be the most essential, namely, nitrogen, phosphoric acid, and potash, are applied singly, in pairs, and in combination of all. Nitrogen is applied in different forms and quantities, and phosphoric acid in different forms; while all are contrasted with a substance valuable both as fertilizer and as feeding stuff, but which is now being chiefly shipped to foreign countries, namely, linseed-oil meal.

[One thousand rods of tile drains, out of the 1,200 rods required in all, were laid the present season. Corn and potatoes were planted in June, while wheat and rotation work were started in the fall.] By another year we hope to have the entire system in operation, yet it will probably be several years before any decisive results can be attained, as the soil under test is naturally fertile, and it will require several years of the improvident practice of continuous cropping without manure to so reduce this natural store of fertility as to show clearly the effect of the different methods of treatment. The report of the agriculturist of the Station will give the results of this season's experiments with corn, and that of the horticulturist the results with potatoes.

[Co-operative experiments by farmers under the direction of the Station have also been planned on a wider scale than formerly.] To some of these certain varieties of grains, fruits, or vegetables have been sent for trial; others have undertaken to carry on experiments in the use of fertilizers under direction of the Station. In all such cases it is required that careful tests shall be made, and the results reported to the Station.

This work was inaugurated on the university farm before the Station was established here, and has been continued and extended since. It is our desire and purpose to still further extend it, and we hope to see the time when there shall be branch stations, directed by intelligent farmers, in every township of our State.

The policy of the Station in devoting itself very largely to field experiments is defended, chiefly on the ground that thus the Station will most quickly and surely gain the confidence of the farmers and lay the foundations for more abstract researches in the future.

We believe the shortest and most direct route to the attainment of this desirable end lies through the performance now by the Station of such work as any intelligent farmer may imitate. Such work, we believe, will more rapidly develop the spirit of research among farmers themselves, and will thus lead to a better understanding of the possibilities and limitations of scientific investigation than would the immediate entrance by the Station upon more elaborate lines of inquiry, to the neglect of these simpler questions. * * *

In brief, the kind of work undertaken by the Ohio Station is that which seems most appropriate to its existing situation and environment, as well as most likely to meet the present requirements of the agriculture of the State. In time it is hoped that the resources of the Station will justify the co-ordination of extensive laboratory work with its field research; but for the present it is deemed best to seek in the field confirmation of the results attained in other laboratories, using our own laboratories simply as a means to this end, as supplementary to our field work, rather than to divide our energies in the attempt—an attempt which, with our present resources, must be futile—to occupy the entire realm of agricultural research.

During the nine months ending December 31, 1888, the Station has employed 63 students of the university (at 12½ cents per hour), and paid them in all $2,846. "The majority of these have worked but a few hours each, but a considerable number have worked quite steadily, and several have earned enough to pay nearly or quite all their expenses in the university."

In order to carry out this policy more effectually the following plan has been arranged by the authorities of the university and Station:

A certain number of students in the agricultural department of the university will be permitted to take one less study during the fall and spring terms than the regular requirement, on condition that they shall be employed half of each day at the Station.

The course of study and hours for recitation will be so arranged that such students may work in relays, one relay working in the forenoon and reciting in the afternoon, and *vice versa.* During the winter term full college work will be required, as the Station does not require so much help at that season, while during the summer vacation these students will give their entire time to the work of the Station. The number of students to whom this opportunity can be offered will of necessity be small at first, and never very large; but it is believed that the work of the Station may be so extended and adjusted that after a year or two fifteen or twenty young men, or even more, may be regularly employed, thus enabling them to pay all the necessary cost of obtaining a thorough scientific education by their labor, and that this labor will be of itself an important factor in that education.

This system, it is argued, will not only benefit the students financially but will prepare them to become trained and skillful station workers, and will also aid in the dissemination of information regarding the work of the Station.

The Station has published seven bulletins during the past season. Hereafter, in accordance with a recent act of the legislature, the monthly bulletin of the Station will be published by the State, and the annual report of the Station, to be included in the report of the State Board of Agriculture, will be a mere summary of the year's operations, with financial statement, etc.

The Station library now numbers about 325 bound volumes, besides numerous pamphlets. The Station officers have access to the university and State libraries. Gifts of agricultural and other journals, apparatus, plants, seeds, etc., are acknowledged.

REPORT OF AGRICULTURIST, J. F. HICKMAN, M. S. A. (pp. 20–99).—Previous to April 1, 1888, the work in this department of the Station was in charge of W. S. Devol, B. Agr., who planned the experiments in wheat here reported. The work of the past year has followed substantially the same lines as that of previous years.

In the experiments with wheat, oats, and corn, we have been aiming to discover the best varieties for particular soils and their adaptation to particular districts of the State; to learn by practical experiment what amount of seed per acre will produce the best results; to learn whether any advantage may be derived from earlier or later seeding than is usually practiced; to investigate the effect of placing the seed at different depths in the soil; and to gather such information as is possible from different methods of seeding or of cultivation.

Experiments with commercial fertilizers upon three crops have also been conducted, but with unsatisfactory results, owing, it is believed, to the richness of the soil used.

Among other investigations at the Station in 1888 were "a field experiment with sugar-beets and mangel-wurzels to determine (1) what variety would give the largest yield, and (2) the effect of barn-yard manure as compared with commercial manures upon these crops; a partial test of several varieties of ensilage corn; a comparison of the yield of several varieties of millet; and a test of cutting timothy hay at different periods of growth."

Two bulletins were published during the year: one on experiments with wheat; the other on the season's experiments with fertilizers for corn.

Experiments with wheat (pp. 23–58).—These included: A. comparison of varieties, including (1) comparative test of varieties at the Station, (2) test of varieties by farmers, (3) classification of varieties. B. Comparison of methods of culture, including (4) thick and thin seeding, (5) early and late seeding, (6) seeding at different depths, (7) methods of seeding.

Comparative test of varieties at the Station (pp. 23–33).—These were on plats comprising one thirty-second of an acre or less. The tabular record includes data for 53 varieties in 1888, the comparative yield of 62 varieties for 8 years, and the comparative yield of the white and red varieties for 8 years. There are also brief descriptive notes on 17 varieties which were not included in the 88 varieties described in the report of the Station for 1887. It appears that in the severe winter of 1887 the smooth wheats suffered more than the bearded varieties. The average yields of these two kinds of wheat for several years have not differed materially, and the same is true of the white varieties as compared with the red.

Tests of varieties by farmers (pp. 34–46).—A tabular record and brief notes for 30 varieties from reports of farmers in different parts of the States who tested the seeds sent them by the Station in the fall of 1887.

Classification of varieties (pp. 46–50).

About 270 differently named sorts of wheat were grown on the Station farm the past season. The object of this work is: (1) to test the adaptation of various sorts to the soil and climate of Ohio; (2) to ascertain whether so-called varieties are true to name, and to determine synonyms; and (3) to accumulate a stock from which to develop new varieties through crossing.

As a first step towards a systematic prosecution of this work, it is necessary to arrange the various sorts in groups, placing in the same group those varieties showing the greatest number of points of resemblance to each other. In the Fourth Annual Report of this Station the varieties were first divided, as they are in this report, into bearded and smooth. In the Fifth and Sixth Reports the color of the grain was made the basis of the first division.

[Since the color of the grain is not a satisfactory basis of classification and yet should be taken into account, a new arrangement of the varieties has been made on the following plan:] We have divided the varieties first into the two classes, bearded and smooth, and subdivided these classes into white and bronze-chaffed, these again being grouped according as the grain is red or white. This arrangement is not without its objections, and it is quite probable that after a more thorough study of this matter of classification we shall have further modification to propose.

In addition to the two hundred and more so-called varieties classified in the report, we have between 35 and 40 crosses which have not been classified. There is here a broad field of investigation to which we hope to give more attention in the future, namely, the detection of synonyms among the great number of so-called varieties.

Thick and thin seeding (pp. 50–52).—A tabular record of the yields calculated from 8 plats where Velvet Chaff wheat was sown September 28, 1887, at the rate of from 2 to 8 pecks per acre, and a comparison of the results of similar experiments for 7 years, during which time the average yield for the 7-peck rate has been 39.9 bushels per acre, while those from the other rates have fallen from 1 to 3½ bushels below this, except that the 2-peck rate has averaged 29.9 bushels and the 9-peck rate 34.1 bushels.

Early and late seeding (pp. 53–55).—A tabular record for 11 plats seeded at intervals of one week from August 23 to November 1 and a comparison of the results of similar experiments for 5 years, during which time the highest average yields (37 to 39 bushels per acre) were obtained from seed planted between September 13 and October 15.

Seeding at different depths (p. 56).

> For three seasons the Station has conducted experiments in sowing wheat at different depths, varying from 1 to 5 inches. From seed placed between 1½ and 4 inches deep the difference in yield has been too slight to justify drawing any conclusions. This year the plat seeded 5 inches deep showed a noticeable falling off in yield, the quantity of straw being proportionately more reduced than that of grain.

Methods of seeding (pp. 56, 57).—A brief report, with tabular record, of an experiment in which the "Lois Weedon" culture, planting with shoe drill alone or followed by wheel press, or with hoe drill followed by roller press, and light (3 to 4 inches) and heavy (8 to 10 inches) mulching, were compared. The light mulch in this case proved injurious and the heavy mulch resulted in an entire failure of the crop.

> *Summary* (p. 58).—*Varieties.*—The Hungarian, Egyptian, Theiss, Tuscan Island, Valley, and Nigger among the red-bearded wheats, are recommended as worthy of trial; of the smooth red wheats, the German Emperor, French Prairie, Michigan Amber, and Wyandotte Red; of white wheats, the Martin's Amber, Democrat, and Silver Chaff (smooth.)
>
> *Quantity of seed.*—While the thick and thin seeding show results favorable to light seeding, we do not recommend for general practice less than 5 pecks nor more than 7.
>
> *Time of seeding.*—South of the forty-first parallel we believe that wheat should be sown after the 10th of September, but in the northern section of the State the sowing may take place earlier.
>
> *Depth of seeding.*—So far as tested, the depth of seeding within reasonable limits does not affect the yield.
>
> *Winter protection.*—The experiments made here in the way of mulching do not justify us in even venturing an opinion until we have given it a further trial.
>
> *Preparation of soil.*—Thorough preparation of the seed bed is one of the great essentials towards securing a good crop. Plow early; stir the ground thoroughly and often; make the surface smooth and level so the water will not stand in low places; then put the wheat in when the ground is in good, friable condition, not too wet, and nature will finish the work without further aid.

Experiments with oats (pp. 59–67).—These were conducted very largely on the plan of previous experiments and included: (1) Comparative tests of varieties, (*a*) at the Station, (*b*) by farmers. (2) Different amounts of seed per acre. (3) Testing secondary effect of commercial fertilizers.

Test of varieties at the Station (pp. 59–63).—This includes general notes on the experiments and a tabular record for 45 varieties grown in 1888, and for the yield of grain per acre, and the weight of a measured bushel of 28 varieties for 5 years.

Test of varieties by farmers (pp. 63–65).—Brief notes on 7 varieties.

Thick and thin seeding (pp. 65, 66).—A brief account of an experiment on 12 plats with as many rates of seeding, from 2 to 16 pecks per acre. The yield rose from 52.7 bushels per acre from the 2-peck rate to 63.5 bushels from the 6-peck rate and then declined to 34.1 bushels from the 16-peck rate.

Effect upon oats of commercial fertilizers applied to the previous crop (pp. 66, 67).—An experiment with Welcome oats on land "on which corn had been grown for several successive seasons, with various kinds and combinations of fertilizers and with no manure."

Summary of results (p. 67).—(1) In the comparative test of 1888 the following varieties show the largest yields: White Schoenen, Race Horse, State of North Dakota, Hopetown, Yankee Prolific, Kansas Hybrid, and Probsteier. These varieties have each yielded about 50 bushels per acre.

(2) The variety most affected by smut was the Black Russian, but out of the 40 or more varieties none were entirely free from smut.

(3) The varieties weighing most to the measured bushel were Badger Queen, Rust-Proof, Welcome, Early Dakota, Clydesdale, and Race Horse.

(4) The variety with strongest straw, Hopetown. This was the only variety that raised up after the rain and wind storm in July.

(5) There is a continuous variation between the results from Clydesdale seed received from Henderson and the seed of the same name received from other sources, Henderson's Clydesdale having a continued advantage.

(6) In a series of experiments continuing over four and five years the following varieties show the largest average yields: White Schoenen, Monarch, Rust-Proof, Barley, White German, Yankee Prolific, Early Dakota, and Kansas Hybrid.

(7) A variety of oats called Harris, distributed by the Department of Agriculture in the spring of 1886, after a three years' trial is pronounced a failure on the soil of the Station.

(8) From seeding at the rate of 6 pecks per acre a larger yield was obtained in 1888 than from heavier or lighter seeding; heavier oats per measured bushel were obtained where less seed was sown per acre, and lighter oats where more seed was sown per acre.

(9) Commercial manures applied to the previous corn crop, but not to the oats, produced no noticeable effect in the crop of oats sown on the corn stubble.

Experiments with corn (pp. 68–99).—These include (1) test of varieties, (2) planting at different depths and at different times, (3) distribution of seed, (4) test of seed from different parts of the ear, (5) different amounts of cultivation, (6) different modes of cultivation, (7) tests with commercial fertilizers.

Test of varieties (pp. 69–77).—This includes general notes on the experiment and a detailed record for 61 varieties in two tables.

The following table gives the averages of those tables by classes:

CORN.—TABLE III.—*Averages of tables I and II by classes.*

Class.	Number of varieties.	Grain.					Fodder, pounds per acre.	Days from planting to cutting.
		Bushels of 70 pounds as harvested.	Per cent of shrinkage.	Bushels of shelled corn January 15.	Weight of shelled corn per bushel.	Per cent of cobs in dry corn.		
Large yellow dent	11	87.0	19.0	71.8	50.5	17.5	2,540	125
Medium yellow dent ...	15	69.7	17.5	59.1	53.2	17.7	1,998	120
Small yellow dent	3	65.8	10.2	60.5	52.2	17.5	1,600	114
Large white dent	7	71.7	22.0	56.8	50.0	18.6	2,770	124
Medium white dent	6	76.8	29.0	50.7	55.2	23.2	3,360	119
Yellow flint.............	11	44.2	17.0	39.9	53.0	21.8	1,240	102
Large white flint	4	72.0	23.5	47.8	50.7	27.7	2,402	122
Mixed flint	3	30.9	20.0	24.2	54.0	15.6	1,000	106
Flour corn...............	1	54.5	50.0	25.9	40.0	24.0	2,020	121

Emphasis is laid on the desirability of thoroughly drying the corn before comparing the results of tests of varieties.

The failure of our attempt to secure such condition by drying samples in barrels has demonstrated the necessity of adopting a more thorough method; and hereafter it is proposed to dry these samples in rat-proof boxes made of wire netting, which shall be so arranged that the air may have free access to and through them, and so that their weight may be conveniently taken from time to time, until a stationary weight indicates that the process of drying is completed. * * *

This experiment shows that corn that was dry enough in October to be safely cribbed lost 10 to 30 or more per cent in weight by January 15 and still was not in all cases thoroughly dry.

Planting at different depths and different dates (pp. 77–83).—A record of experiments during six years in planting at depths of 1 to 4 inches and at different dates from April 26 to June 14. The results are quite variable, but in general indicate that in the climate of the Station corn should be planted in May and not deeper than 2 inches.

Distribution of seed (pp. 83–85).—A tabular record of the yield of grain and fodder and per cent of ears and nubbins for fourteen different rates of distribution of the seed. In this, as in previous experiments at the Station, it appears that thick planting (6 inches apart) increases the yield of fodder and the per cent of nubbins.

Where the stalks average 6 inches apart the average of full-sized ears is reduced to 54 per cent—nearly one-half. The average yield is as high, or higher, where the stalks average 12 inches apart, and the large ears average 82 per cent, or more than four-fifths. Where the stalks average 18 inches apart the average total yield of grain is reduced by about 14 bushels per acre, while the per cent of large ears is not materially increased.

Where two grains were planted every 6 inches we have maximum of the nubbin yield—70 per cent. This is what any practical farmer would expect from such close planting.

Seed from different parts of the ear (pp. 85, 86).—Three duplicate plats were planted with seed "from the butts, the middle, and the tips" of the ears. The results, as tabulated, show too slight variations to justify conclusions. The tabular record of a similar experiment in 1886 is also given.

Different amounts of cultivation (pp. 86, 87).—A brief account and tabular record of an experiment in which corn was cultivated from three to seven times from June 16 to August 3. This experiment, like previous ones in this line at the Station, fails to show any advantage from excessive cultivation. "Three cultivations, when judiciously distributed, have thus far given as good yields as the best."

Commercial fertilizers on corn (pp. 88–99).—General notes, diagram, and tabular record for an experiment at the Station in 1888 on 22 tenth-acre plats, where dissolved bone-black, muriate of potash, and nitrate of soda were used singly, two by two, and all three together, and compared with barn-yard manure, linseed-oil meal, and no manure. No beneficial results were apparent from the use of fertilizers. The experiment will be continued. Farm tests in different parts of the State under direction of the Station are being planned, and one such test was made in 1888 "in the eastern part of the State (Columbiana County). The location is on a high 'soap-stone' or slaty point. This stratum of slate is possibly 10 feet deep, and that, with its elevation, gives abundance of natural drainage. The natural condition of this kind of soil is quite loose and open, and always easily worked. We are justified in saying that fully one-half of this soil is made up of small slate stones, from the size of a ten-cent piece up to and somewhat larger than a silver dollar. In general terms it is considered poor land—just the place for such investigations as we wish to make."

The plan of the experiment was similar to that used at the Station. The results are recorded in two tables. The following conclusions regarding both experiments with fertilizers are taken from the report:

> *Conclusions.*—From the experiment conducted on the Station land we can find some slight indications of the effects of the fertilizers, but they are so slight that we deem it best not to attempt to draw any definite conclusions from this single experiment, further than to say that in our opinion the work gives evidence that a soil that will produce from 80 to 100 bushels of shelled corn per acre is not benefited by the addition of commercial fertilizers. From the farm test, however, made on soil of less natural fertility we deduce the following conclusions with respect to that particular soil:
>
> (1) This work proves that the plan of experimenting is not at fault, but shows that the application of commercial manures is in some cases attended with good results.
>
> (2) It indicates that potash and phosphoric acid applied either alone or the two combined do not increase the yield over unfertilized land.
>
> (3) It shows that nitrates applied either alone or in combination with either phosphoric acid or potash, or applied in combination with both, add to the yield per acre.
>
> (4) The increase in yield is made in two ways: first, by causing many of the otherwise barren stalks to produce ears; and second, by reducing the percentage of nubbins.
>
> (5) Nitrates used alone or in combination also increased the weight of the fodder per acre.

REPORT OF HORTICULTURIST, W. J. GREEN (pp. 100–127).—The work for 1888 was in the following lines: (1) comparisons of varieties and strains of varieties; (2) comparisons of effect of fertilizers upon crops, both upon quantity and quality of product; (3) comparisons of methods of planting and cultivation; (4) comparisons of methods of treating seeds; (5) observations upon the effect of selection as illustrated by strains of varieties; (6) observations on the influence of soil and climate upon the growing of seeds, as shown in vitality, vigor of plants produced, and the resulting crops; (7) experiments in ripening and keeping fruit.

The tests of varieties have been modified with a view to learning their probable value at the earliest practicable date. To this end duplicate tests have been made, and seeds and plants have been sent to practical growers in different parts of the State. The lists of old varieties have been much shortened by rejecting those unworthy of cultivation, and particular attention has been called to the varieties worthy of general cultivation, the old as well as the new. "Whenever practicable the work has been carried on on a larger scale than formerly, by increasing the size of the plats, thus adding to the trustworthiness of the results."

Strawberries (pp. 103–111).—Experiments in setting plants in the fall indicated that planting later than August 1 is not usually desirable in the latitude of the Station, though by close planting gardeners might profitably grow strawberries as a second crop, with a smaller yield than the first. A tabular record and brief descriptive notes are given for 25 varieties. Superphosphate, nitrate of soda, sulphate and muriate of potash, sulphate of ammonia, bone meal, common salt, and barn-yard manure have been applied singly to strawberries and compared with no manure since 1885. Analyses of samples of the Crescent variety grown in 1888 are given, which indicate that the fertilizers used had no effect on the composition of the berries.

So far as taste and appearance of the fruit were concerned, no difference could be detected in the samples from the several plats. In two other respects, however, there were decided differences. The fruit ripened several days earlier on the superphosphate plat than upon the nitrate of soda plat, and upon another plat where sulphate of ammonia was used the difference in time of ripening was still more marked, so much so that at the time the other plats were picked a sufficient quantity of fruit for picking could not be found on this plat. The difference in growth of the plants and color of foliage was also very marked. The plants on the superphosphate plat and unfertilized plats could hardly be distinguished; but those on the nitrate of soda plat were much stronger in growth, and the foliage was of a darker green color than those named; while the extreme was still greater where sulphate of ammonia was applied. Potash seemed to have no appreciable effect on the growth and color of the foliage. It was also evident that while sulphate of ammonia and nitrate of soda promoted growth of foliage, they decreased the quantity of fruit.

Analyses of 5 other varieties are also reported.

It will be seen that there is quite a difference in the per cent of seeds in the varieties named, but the per cent in all is quite low in comparison with the wild strawberry. Professor Weber, in a paper before the Columbus Horticultural Society, in speaking of 2 varieties, says: "According to Fresenius, the wild strawberry contains 6 per cent of seeds. The Crescent seedling was found to contain 1.52 per cent seeds, and an unnamed seedling 1.5 per cent seeds. In other words, the amount of seeds in these two cultivated varieties has been reduced 4.5 per cent, or 75 per cent when compared with the seed content of the original wild berry."

Raspberries (pp. 111–114).—Brief notes on 17 varieties and a record of analyses of 6 varieties.

Blackberries (pp. 114, 115).—Brief notes on 13 varieties.

Summary of small-fruit experiments (pp. 115, 116).

STRAWBERRIES.

Varieties.—From tests thus far made on the Station grounds, we recommend as worthy of trial among the newer sorts, for market purposes, Bubach, Gandy, Haverland, Jessie, Ohio, and Pearl. The following possess points that make them desirable for amateurs: Anna Forest, Covell, Gold, Jewell, Lida, Norman, and Ontario. The following are either undesirable or doubtful, and require further trial: Warfield, Mammoth, Monmouth, Belmont, Parry, Truit's Surprise, Bomba, Carmichael, Hoffman's, Itasca, Logan, Louise, Sunapee.

Effect of fertilizers.—In our experiments different fertilizers have had apparently no effect upon the quality of the fruit. Fertilizers containing nitrogen have reduced the quantity of fruit, at the same time promoting the growth of foliage.

Quality.—Chemical analysis exhibits considerable variation in the percentage of sugar and acid in the different varieties, but there seems to be no direct relationship between this percentage and the quality of the fruit. In other words, flavor seems to be a more important factor in determining the palatableness of the fruit than either sweetness or acidity.

RASPBERRIES.

Varieties.—Of the newer varieties, Ada, Golden Queen, Hilborn, and Tyler are recommended as worthy of trial. The following are still in doubt and need further trial: Marlboro, Johnston's Sweet, and Rancocas. The Crimson Beauty, Cuthbert, Hansell, and Nemaha have not proved satisfactory on the Station grounds.

Quality.—As with strawberries, so with raspberries, chemical analysis fails to reveal the secret of palatableness. Incidentally, however, it shows that the relative proportion of seeds becomes, in some cases, an important factor in judging the relative merits of different varieties.

BLACKBERRIES.

For general planting in Ohio, of the varieties thus far tested at the Station, the Ancient Briton, Agawam, Snyder, and Lucretia Dew-Berry are recommended. The Erie, Early Harvest, and Minnewaski are worthy of trial. Wilson Junior, Novada, Topsy, Bonanza, and Early King are too tender for this latitude.

Potatoes (pp. 116–127).—A tabular record for 47 varieties grown at the Station, and for a number of varieties grown by farmers in different parts of the State.

Taking the evidence of these trials we may rank the varieties in the following order in respect to productiveness: Empire State, Summit, Early Oxford, Pearl of Savoy, Potentate, Puritan, Lee's Favorite, Early Rose, Charles Downing, Early Standard, Early Albino, Early Ohio, and Ohio Junior.

As regards earliness, these varieties would in general rank in reverse order. Descriptive notes are given for 17 of the most important old and new varieties. The effect of drying seed 5, 9, and 12 days was tested with three varieties.

Drying for 5 days seems to have been slightly beneficial in two cases and injurious in a third. The effect of 9 days' drying appears to have increased the productive capacity in all cases, while 12 days' drying resulted in injury in two cases, as compared with 9 days' drying, and seemed to have no effect in a third.

This agrees in a general way with the result of a similar experiment at the New York State Station.

REPORT OF ENTOMOLOGIST, C. M. WEED, M. S. (pp. 128–176).

Insect record for 1888 (pp. 131–134).—Notes on insects which have been injurious to agriculture in Ohio during 1888, including the chinch-bug (*Blissus leucopterus*), grain plant-louse (*Siphonophora avenæ*), Hessian fly (*Cecidomyia destructor*), rose beetle (*Macrodactylus subspinosus*), pea-weevil (*Bruchus pisi*), bean weevil (*Bruchus obsoletus*), canker-worm (*Anisopteryx vernata*), codling moth (*Carpocapsa pomonella*), plum curculio (*Conotrachelus nenuphar*), clover root-borer (*Hylastes trifolii*), clover-seed midge (*Cecidomyia leguminicola*), and clover hay-worm (*Asopia costalis.*)

Some experiments in preventing the injuries of the plum curculio (pp. 134–150).—A detailed record of a extensive experiment in spraying cherry-trees with London purple and lime, and a brief account of similar experiments with plum and pear trees. The life history and feeding habits of the curculio as compiled from various sources are also given, and evidence regarding the use of poisons for this insect is quoted from Bulletin No. 39 of the Michigan Station and from other sources. The conclusions drawn from the season's experience are thus stated:

(1) A large proportion of the fruit liable to injury by the plum curculio may be saved by spraying with London purple or Paris green.

(2) The preventive effect of these poisons is probably due to their action upon the adult insect, when taken into the system with the fruit and foliage consumed for food.

(3) If an interval of a month or more occurs between the last application and the ripening of the fruit, no danger to health need be apprehended from its use.

(4) Lime is less effective than London purple, and good results are more likely to be obtained from its application to plums than cherries, its preventive effect depending almost wholly upon the extent to which each fruit is coated. It is also to be remembered that while London purple kills the insect, lime simply drives it away.

A practical preventive of rose-bug injuries to grapes and peaches (pp. 150, 151).—An account of the successful use of lime by Mr. E. A. Dunbar, of Ashtabula, acting under advice of the entomologist of the Station, to drive away rose-bugs from a vineyard and peach orchard.

On some insects affecting currants and gooseberries (pp. 152, 153).—Notes on the green apple leaf-hopper (*Empoa albopicta*, Forbes), four-striped plant bug (*Pœcilocapsus lineatus*, Fab.), and the imported currant worm (*Nematus ventricosus*, Klug), with suggestions as to remedies.

Notes on some raspberry insects (pp. 154–156).—These include the raspberry cane borer (*Oberea bimaculata*, Oliv.), tree cricket (*Œcanthus niveus*, Serv.), and raspberry slug (*Selandria rubi*, Harr.).

On the autumn life history of certain little-known plant-lice (pp. 156–159).—Notes on the currant plant-louse (*Myzus ribis*, Linn.), and the willow grove plant-louse (*Melanoxanthus salicti*, Harr.).

Notes on various insects affecting garden crops (pp. 160–162).—These include the cabbage plusia (*Plusia brassicæ*, Riley), striped vine beetle (*Diabrotica vittata*, Fab.), and celery worm (*Papilio asterias*, Cram.).

Heat as a remedy for pea and bean weevils (pp. 163, 164).—It was found that the larva of the pea-weevil could be destroyed by exposing the seed of the pea to a heat of 145° Fah., which was not sufficient to injure the germinating quality of the seed. It was inferred from this experiment that the same would be true of the bean weevil.

On the chinch-bug in Ohio (pp. 164–167).—A compiled account of the life history of this insect and of diseases which have destroyed it in large numbers, and brief statements regarding experiments at the Station with preventive remedies.

On two potato insects (pp. 167–169).—Notes on the imbricated snout beetle (*Epicaerus imbricatus*, Say), and the Colorado potato beetle (*Doryphora 10-lineata*, Say).

On injuries of the spotted grapevine beetle (pp. 169, 170).—Notes on the *Pelidnota punctata*, Fab.

List of articles published by the entomologist during 1888 (pp. 171–176).—This includes 7 technical and 45 economical and popular articles.

REPORT OF VETERINARIAN, H. J. DETMERS, D. V. M. (pp. 177–180).—This contains brief notices of investigations by the author on a skin disease of cattle, swine plague, colic in horses, and the germs of yellow fever in man.

REPORT OF METEOROLOGIST, MOSES CRAIG (pp. 181–199).—This includes detailed tabular records of observations during 1888, summaries of observations for 6 years, and notes on weather of the year.

The importance of this work was early appreciated at this Station, and soon after its establishment, in 1882, the necessary instruments were procured and systematic observations on temperature and rain-fall begun, a careful record of which has since been kept.

These observations are made daily, at 7 a. m., 2 p. m., and 9 p. m., local time. At these hours the following phenomena are noted: (1) atmospheric pressure; (2) air temperature; (3) humidity of the air; (4) direction and velocity of the wind; (5) amount and kind of clouds, with the direction from which they are moving; (6) amount and frequency of rain-fall; (7) other phenomena of interest, as the occurrence of frost, hail, thunder-storms, etc.

APPENDIX: HISTORY, ORGANIZATION, AND WORK OF THE STATION (pp. 202–211).—The Station was established by an act of the State legislature passed April 17, 1882, and amended April 18, 1883, and March 15, 1888. The full text of the act in its present form is given in this article, together with brief accounts of the first organization, changes in the organization, and the text of the act of Congress of March 2, 1887. The provisions of this act were accepted by the legislature of the State February 9, 1888, in a joint resolution, the text of which is given in this article. There is also a brief account of the organization of the Station under an act of Congress, the articles of agreement between the university and the Station relative to the Station, and the outline of the proposed work of the Station under the new arrangement. The university transferred the entire cultivated portion of its farm to the control of the Station. The Station purchased the live stock and implements of the university and agreed to employ student labor as far as practicable.

PENNSYLVANIA.

The Pennsylvania State College Agricultural Experiment Station.

Department of the Pennsylvania State College.

Location, State College, Centre County. Director, H. P. Armsby, Ph. D.

ANNUAL REPORT FOR 1888.

[The Report of the Station is published as Part II of the Report of the Pennsylvania State College for 1888.]

REPORT OF DIRECTOR (pp. 15-18).—The director took charge of the Station at the close of 1887, and while experimental work was actively carried on at the Station, and its scope considerably extended during 1888, a large portion of time was necessarily devoted to questions of organization and equipment. The corner stone of a new Station building was laid June 27, 1888, and the building was nearly completed within that year.

The Station proposes to undertake three kinds of work:

(1) Experiments designed either to add to our knowledge of the principles involved in the successful production of crops and animals, or to show the best methods of applying in practice principles already established. * * * It does not expect to confine itself in this branch of its work exclusively, or even largely, to purely scientific experiments; that is, experiments designed to establish principles. It will rather regard it as its chief duty to apply scientific methods to the study of practical questions, that is, questions of practice as distinguished from questions of science; and while desiring to emphasize the importance and value of scientific research, and endeavoring to do as much of it as it deems consistent with its other duties, it will consider that its first obligation is to inform the farmers of the State upon those points on which they desire information.

(2) In addition to this work of general interest to all farmers, special questions often arise of peculiar interest to one or a few farmers, such as the value of some new kind of fodder; the purity and germinative power of a lot of seed offered or purchased; the name and value of a new grass or other plant; the name and habits of a new insect, etc. The Station will endeavor, to the extent of its power, to aid farmers

by examining specimens of the various farm products, fodders, etc., sent to it; identifying plants, grasses, weeds, and insects; testing seeds, etc. * * *

(3) The Station will aim to make itself useful as a bureau of agricultural information.

"The system of field experiments which has been carried on for several years upon the central experimental farm has been continued without material change during the past year. Full meteorological observations have also been continued during the year." In view of the importance of live stock as a means not only of direct profit to the farmer, but even more of preserving and increasing the fertility of the soil, considerable attention has been given to problems relating to the feeding of animals, and more work in this direction is planned. "In this work it is proposed to pay particular attention to questions bearing on the economy of feeding, and to endeavor to furnish some aid to the farmers of the State in reducing the cost of production of meat and dairy products."

The list of bulletins published in 1888 includes: No. 2, January, Field Experiments with Phosphates; No. 3, April, Composition and Digestibility of Corn Stover; No. 4, July, Seed Germinations; No. 5, October, The Digestibility of Soiling Rye. A small pamphlet, entitled List of Experiments in Progress, was also issued in August and distributed at the State Fair at Philadelphia and elsewhere. The mailing list of the Station now numbers over 11,000 names.

THE NEW STATION BUILDING, H. P. ARMSBY, PH. D. (pp. 19–25), (illustrated).—This contains a description of the building, reprinted from Agricultural Science for September, 1888, with plans of the front and side elevation and of the first and second floors, and the address of Professor I. P. Roberts, of Cornell University, at the laying of the corner stone.

The building consists of a main portion 68 feet 6 inches by 42 feet in extreme dimensions, and two stories high, with an additional story in the tower over the main entrance; and of a one-story wing 44 feet 8 inches by 24 feet 9 inches; placed at right angles with the main portion of the building. It contains offices, chemical and botanical laboratories, library, museum, and rooms for assistants.

The building above the foundation is of wood, brick-cased up to the transoms of the first-story windows, and shingled above that point.

The interior will be finished in first quality white pine, finished in the natural wood, with Southern yellow pine floors throughout the building. It will be heated by steam, and gas will be furnished from a naphtha gas machine.

TESTS OF VARIETIES, 1888, W. H. CALDWELL, B. S. (pp. 26–47). *Corn* (pp. 26–35).—This is a record of experiments in 1888, to study the adaptability of some varieties of field corn to this section, and to make observations "upon the yield of the corn planted, at different stages of its growth. They were performed on twentieth-acre plats of old sod land. No fertilizer was used. The varieties tested were: (1) *Silage corn*—Breck's Boston Market Ensilage, Blount's Prolific. (2) *Dents*—Chester County Mammoth, Golden Beauty, Golden Dent, Mammoth

White Surprise, Pride of the North, Smedley, and White Giant Normandy. (3) *Flints*—Self-Husking, Thorburn's Golden Yellow, Tuscarora. Samples for chemical analysis were taken at four different stages of growth: (1) when fully tasseled; (2) ears beginning to fill out; (3) kernels beginning to glaze; (4) fully ripe. Results are stated in tabular form, including yields per acre, at the different stages of growth (as computed from yields of single rows), of corn as harvested and weighed, and of dry matter as indicated by analysis. This season's work implies":—

That for field crops such varieties as the Golden Beauty, Golden Dent, Smedley, and Pride of the North are the best adapted for this and the northern sections of the State. The Chester County Mammoth, Mammoth White Surprise, and White Giant Normandy may be used successfully in the southern portion as a field crop. With us they did not mature, and could only be used for fodder. The question of merit would then largely turn on the palatability of the stalks and their digestibility. The facilities of the Station would not allow the determination of the latter.

"As the increase of total weight of dry matter should include all the nutritive materials and all water from period to period, the figures show that with these experiments (1) while the percentage of water decreases as the plants advance in growth the absolute amount of water increases; (2) as the plants approached maturity there was a rapid increase of dry matter per acre, in many instances the amount of dry matter in mature stover alone being equal to or more than that of the total crop at any other period of the growth; (3) by allowing plants to mature there is considerably less water to be handled in proportion to the amount of actual food material than there would be if they were cut and used when the kernels began to glaze. At the same time the amount of valuable material (dry matter) is much greater.

"The following points are given for 'guidance in the culture of the corn crop:'"

Good seed, purchased of reliable dealers or judiciously selected from previous season's crop.

Thorough plowing and pulverization of the ground.

Not too close and heavy planting, as for success there is needed exposure to sunlight and air.

Frequent cultivation and with as little manual labor as possible.

Not too much haste in harvesting, as it is shown from the results of this year's experiments that if the crop is allowed to mature there will be a considerable gain in valuable material for feeding purposes. At the same time, the economy of harvesting will be greater, as there is relatively less water to handle.

Remarks on the foregoing experiments.—These are by the director of the Station. Corn is shown to be one of the most important crops in Pennsylvania. According to the census of 1880 it occupied almost as many acres and produced nearly two and one-half times as many bushels of grain as the wheat crop. With corn at 45 cents per bushel the 46,000,000 bushels produced in 1880 would be worth over $20,000,000, while the 19,500,000 bushels of wheat at 90 cents would be worth about $17,500,000. If we add the value of the stover and forage corn, it is probable that $35,000,000 is a low estimate of the value of the annual corn crop of this State. The perfection of the process of ensiling has made it especially desirable that the Station should study the value of corn as a forage crop, both by comparing varieties and by observation of the yield and composition at different stages of maturity. "The results reached in regard to growth of the crop in its later stages are worth the careful attention of our farmers." Many other experiments have shown the rapid increase of dry matter per acre in later stages of the growth of corn. How far this increase can be utilized for forage is an important question and one upon which further data are desirable. "With our present knowledge it seemed doubtful whether corn grown for silage should be allowed to stand much longer than until the kernels are beginning to glaze." To secure the largest yields of corn, a variety should be selected which could nearly or fully mature in this locality, and the crop should be permitted to grow until well advanced toward maturity. The results of experiments made at this Station on the digestibility of young corn fodder and stover show that while the former is more digestible the difference is not very great. "The general conclusion to be drawn from our experiments, then, as to the proper time of harvesting corn is that it should be allowed to stand as long as the climate of the locality and the purpose in view will permit, since it is continually increasing in value per acre."

Wheat (pp. 35–37).—The six varieties tested in 1888 are briefly described, mainly by quotations from the Report of the United States Department of Agriculture for 1887.

The varieties tested were: Sibley's New Golden, Fulcaster, Raub's Black Prolific, German Emperor, McGhee's White, Extra Early Oakley. The yields per acre of grain and straw in 1887 and 1888 are stated. German Emperor gave the best results both years, and Raub's Black Prolific stood next in yield in 1887, and Fulcaster in 1888. The Extra Early Oakley matured earliest of all in both seasons, but its yield was small.

Oats (pp. 37, 38).—The varieties tested were White Victoria, Japan, Wide Awake, Henderson's Clydesdale, Welcome, Harris. The best results were obtained from Japan and Wide-Awake.

Barley (pp. 39–41).—The varieties tested were Hulless or Nepaul, and Manshury. The Nepaul produced the heavier grain, but not as many bushels per acre as the Manshury. A letter from Dr. Grunow, of Mifflin, Wisconsin, from whom the seed of the Manshury barley was first disseminated in this country, states that the barley was first introduced into Germany under the name of Mandschurei or Mandschurey, from the country where it was found (the northwestern part of the Chinese Empire).

Potatoes (pp. 41–43).—The varieties tested were Thorburn, Vanguard, College White, Monroe County Prize, Early Ohio, Early Beauty of

Hebron, Dakota Red. None of the others equaled the College White, the variety usually grown on the college and Station farms.

Forage crops (pp. 43–47).—The varieties tested were prickly comfrey, Kaffir corn, black-eye variety of cow-pea, teosinte, white mustard, Brazilian or flour corn. Only the first three seemed to merit further trial. Samples of the white mustard, Kaffir corn, and prickly comfrey, the last at three stages of development, were analyzed. The actual yields per acre, and the quantities of digestible nutrients computed by comparison of total yield, composition, and assumed co-efficients of digestibility, were as follows:

Total produce and digestible nutrients.

[Pounds per acre.]

	Prickly comfrey.	Kaffir corn.	Cow-peas.
Total crop per acre	16, 500	11, 000	14, 500
Digestible protein	221. 0	119. 4	280. 9
Digestible fat	30. 5	34. 2	53. 9
Digestible carbohydrates	658. 4	941. 0	937. 0
Total digestible organic matter	909. 9	1094. 6	1271. 8

FEEDING STANDARDS AND COMPOSITION OF FEEDING STUFFS, H. P. ARMSBY, PH. D. (pp. 47–54).—This contains a popular discussion of the chemical constituents of the bodies of animals and of plants, tables showing the average composition of the bodies of oxen, sheep, calves, and swine, Wolff's feeding standards, the composition of a large number of feeding stuffs, "taken chiefly from Dr. E. H. Jenkins's Compilation of American Analyses," and illustrations of the method of compounding rations.

THE SOILING SYSTEM FOR MILCH COWS, H. P. ARMSBY, PH. D., WM. FREAR, PH. D., H. J. PATTERSON, B. S., G. L. HOLTER, B. S., W. H. CALDWELL, B. S., AND W. S. SWEETSER, B. S., REPORTED BY H. P. ARMSBY (pp. 54–105).—After brief introductory remarks on the comparative merits and economy of pasturage and soiling for milch cows, the author proceeds to the consideration of investigations made at the Station, under the following heads: (1) the yield and composition of pasture grass; (2) the digestibility and nutritive value of young grass; (3) a comparison of the digestibility and nutritive effect of green and dried grass (hay); (4) the digestibility of soiling crops; (5) the yield and nutritive value of soiling crops; and (6) a comparison of soiling and pasturage.

Yield and composition of pasture grass (pp. 55–77).—"The object of this experiment was to obtain data as to the chemical composition of pasture grass and the amount produced per acre as a basis for comparison with soiling crops."

Having no pastures, it was necessary to find some spot which should represent as nearly as might be an average pasture. For this purpose a portion of the college campus was selected where the grass did not appear particularly luxuriant, or, on the other hand, especially thin. The grass was an old blue-grass sod, with quite a liberal admixture of white clover, having a gradual slope to the southeast. A plat 1 rod wide and 7 rods long was staked out and subdivided into 7 portions each 1 rod square. The grass upon this plat was cut with a lawn mower having attached to it a grass box which caught all or practically all the grass as it came from the knives. The subplats were cut in this way, one at a time, in regular rotation throughout the season, the grass after cutting being taken to the laboratory as promptly as possible, accurately weighed, and sampled for analysis. The object of subdividing the plat into 7 subplats was to follow the daily rate of growth as closely as possible, and the intention was to cut one subplat each day. It was soon found, however, that daily cutting was too frequent, and during nearly all of the experiment the time of cutting was governed by the growth of the grass. Each successive set of 7 samples taken as above, and consequently representing the yield of the whole plat, was united and subjected to chemical analysis. * * *

[The average composition of the grass is given as follows:]

Composition of pasture grass.

	Fresh.	Water free.	Wolff's average, water free.
Water	73.37	....	....
Ash	2.46	9.23	10.0
Albuminoids	5.54	20.85	12.5
Non-albuminoids	0.28	1.04	4.7
Crude fiber	4.85	18.25	20.0
Nitrogen-free extract	11.81	44.39	48.5
Fat	1.69	6.24	4.0
	100.00	100.00	100.0

Of the total amount of nitrogen found in the grass only 4.98 per cent was found to be in a non-albuminoid form, the remainder being, so far as our means of analysis can show, in the form of true protein. * * * Our samples were taken at an earlier stage of growth than most of those represented by Wolff's average, and consequently we find in our average considerably more protein and somewhat less crude fiber.

After calling attention to the difficulties in the way of an accurate determination of the yield of total and digestible food ingredients from an acre of pasture, since the term pasture "has a very wide range of meaning," and the results on any field are liable to be influenced by the condition of the season, etc., he says: "Taking the results as they stand and for what they are worth, we find the total yield of green grass per acre, from the beginning of the season to October 30, to have been 4,276.82 pounds, and that this amount of green grass contained 1,145.49 pounds of dry matter." No determination was made of the digestibility of this grass, but the co-efficients found for a grass "cut at a rather later stage of growth" are used, "for want of better results," in calculating the yield of digestible food ingredients per acre.

This yield, as tabulated, is as follows:

Total yield of digestible ingredients per acre.

Albuminoids	160.42
Non-albuminoids	*12.37
Carbohydrates (fiber and nitrogen-free extract)	529.64
Fat	40.69

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* Assumed to be wholly digestible.

To get an idea of the relative rate of growth, calculations were made of the total yield of dry matter and of digestible dry matter during each of nineteen periods from May 10 to October 25, the average of the seven subplats being taken. These data are tabulated and illustrated by means of a diagram.

It is evident both from the table and the diagram that there was a rapid falling off after the early spring growth, doubtless exaggerated somewhat in this case by the dry weather of June and possibly by the too frequent cutting. Still the results are such as might be reached on fully stocked pastures. The point most worthy of notice is the great variation in the yield at different times, it being from five to eight times as great in early spring as in August. The result of this is that if a pasture is stocked to its full capacity in the spring, it is overstocked in midsummer, and both the pasture itself and the herd suffer. On the other hand, if only as much stock is placed on the pasture as it can carry throughout the season, the early spring growth is not utilized. The only way in which this difficulty can be overcome is by supplementing the pastures with other feed during the summer, either in the form of soiling or of grain feed.

The average daily growth of pasture grass from May 10 to September 29 (after which the yield was very small), is calculated as follows:

	Pounds per acre, daily.
Fresh grass	25.17
Total dry matter	7.70
Digestible:	
Albuminoids	1.08
Non-albuminoids	0.08
Carbohydrates (fiber and nitrogen-free extract)	3.57
Fat	0.27
Total digestible organic matter	5.00

Effect of drying on the digestibility and nutritive effect of grass.—This is a report of a digestion experiment with a 5-year-old Guernsey-Jersey cow, to compare the relative digestibility of freshly cut grass and hay. The general plan of the experiment was as follows:

On the afternoon of each day there was cut on the college campus somewhat more than 165 pounds of grass. * * * A sample of 5 pounds was first taken for chemical analysis; then 80 pounds were weighed out for the animal, about half being given to it the same night and the remainder kept covered in as cool a place as possible and used for the next morning's feed. Finally a second portion of 80 pounds was weighed out and spread on a large sheet to dry [artificially]. * * * When thoroughly dried the whole amount for one day was carefully transferred to a cloth bag, tied up securely, and set aside. This routine was gone through with daily throughout the first period of 18 days. During the last five days of this [first] period the digestibility of the grass was determined [in the usual manner]. * * * In the second period of the experiment, also extending over 18 days, the dried grass from the previous period was fed, the grass dried on the first day of the first period being fed on the first day of the second period and so on throughout. The digestibility of the dried grass was determined during the last five days of the period.

The co-efficients found were as follows:

Percentage digestibility.

Period.	Fodder.	Dry matter.	Ash.	Total protein.	Albuminoids.	Crude fiber.	N. free extract.	Fat.
I	Green grass	68.7	49.7	65.5	55.5	74.3	72.5	54.7
II	Dried grass	71.3	55.5	71.5	63.2	76.7	72.9	60.1

"The results show an apparently greater digestibility for the dried than for the green grass."

The table and diagram showing the live weight of the animal in each period indicate that, "while the weight of the animal was decidedly less in the second period on the dried grass than in the first period, the falling off of weight in passing from the one period to the other was a sudden one." The author believes for this reason that the falling off in live weight in the second period was not due to deficient nutrition, but "to a decrease in the contents of the stomach and intestines due to the change of food."

With regard to the nutritive effect of the two rations as indicated by the quantity and composition of the milk, which are stated in tables, the author concludes that, all things considered, "the green grass and the dried grass were substantially equal in nutritive effect." The article also contains a summary of the results of a similar experiment made by the author at the Wisconsin Station (see Wisconsin Station Annual Report, 1887), and of experiments made at Houghton Farm,* at the New York State Station,† and at the Wisconsin Station,‡ as to the churnability of fat when dried and when succulent rations were fed.

> The experiments described above, taken in connection with what is already known on the subject, lead to the conclusion that the simple drying of grass without loss does not diminish either its digestibility or its nutritive value as a food for milch cows, with the single exception that dried food appears to influence unfavorably the churning qualities of the milk. * * * Pasture grass is better than hay, because it is cut earlier, and is therefore of a better quality *per se.* It is a perfectly well-established fact that the earlier grass is cut the greater is its percentage of protein and the less its percentage of crude fiber, both of which circumstances give greater value to the young grass.

Illustrative of this latter point the author cites European experiments § in which determinations of the composition and digestibility of grass cut from the same meadow, May 14, June 9, and June 26, indicated the grass from the earlier cuttings to be of better quality and more digestible. "Grass is better than hay because in the ordinary processes of making hay there is considerable loss of material. The leaves and tender parts, which are especially valuable, become dry first and crumble off more or less before the stems are sufficiently dried."

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* Society for Promotion of Agricultural Science, 1883–84, p. 23.

† New York State Station Annual Reports, 1883–1885.

‡ Wisconsin Station, Fifth Annual Report, 1888, p. 52.

§ Landwirthschaftliche Jahrbücher, 8, Supplement I, p. 54.

Digestibility of soiling crops (pp. 77–95).—This includes determinations of the co-efficients of digestibility of green rye, clover, and corn fodder as used for soiling purposes. The rye used in the experiment "was well advanced in maturity for soiling purposes when the experiment was begun, and before it was completed had become a little more mature than is desirable in practice." The clover was a very rank first-year's growth with coarse stems. "The material used was more mature than the average crop fed in practice. The heads had, in great measure, turned brown before the completion of the experiment." The corn was a dent variety, and was grown in drills 3 feet apart. "It was 4 or 5 feet high at the beginning of the feeding, but before the close had grown considerably, though it had not begun to harden. It was fully as young as would be fed in practice."

For these experiments two grade Devon steers were used, 2-year-olds, of about 700 pounds weight. Previous to the beginning of the experiment proper, these steers were fed with indefinite quantities of the material to be experimented upon, so as to displace from the alimentary canal the residue of all other foods which would interfere with the successful conduct of the experiment.

After this the feeding of definite quantities was begun * * * and was continued for 1 week before the collection of dung was begun. This last operation was carried on for 5 days, the urine being caught in a rubber bag strapped to the steer, while the dung was caught upon shovels as it dropped, by the watchmen who were stationed with the animals night and day during this last period.

The food was cut, well mixed, and an aliquot portion taken for analysis each day, starting with the time when the feeding of definite quantities was begun. * * * Any material that the steers left in the manger or pulled over onto the floor was gathered up, weighed, and sampled for analysis.

The animals were weighed and watered upon the scales daily at noon, being kept in the stable during the rest of the time upon a bedding of sawdust. The dung was weighed at the end of each succeeding 24 hours, and an aliquot portion taken for analysis.

About 80 pounds of freshly cut green rye, 80 pounds of green clover, or 100 pounds of green corn fodder were fed per animal daily, no other food being given.

There was no considerable change in the live weight of the animals during the experiment. The data obtained in the experiment and from which the co-efficients of digestibility were calculated are tabulated in detail. The figures found were as follows:

Co-efficients of digestibility.

	Green rye.			Green clover.			Green corn fodder.		
	Steer No. 1.	Steer No. 2.	Average.	Steer No. 1.	Steer No. 2.	Average.	Steer No. 1.	Steer No. 2.	Average.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Dry matter	73.2	74.0	73.6	67.3	64.9	66.1	70.2	67.2	68.7
Crude ash	56.1	55.0	55.5	56.7	53.4	55.0	63.5	57.9	60.7
Crude cellulose	78.9	80.4	79.6	52.9	52.3	52.6	75.6	73.8	74.7
Crude fat	74.8	73.6	74.2	66.1	63.0	64.5	37.5	42.6	40.0
Crude protein	79.7	78.6	79.1	68.3	65.8	67.0	79.9	76.4	78.1
True albuminoids*	57.3	55.0	56.1	64.5	62.2	63.3	72.3	76.3	74.3
Nitrogen free extract	69.7	71.4	70.6	79.2	76.1	77.6	67.7	64.0	70.8

* Calculated by assuming the non-albuminoid protein to be wholly digestible.

The composition and digestibility found for the above soiling crops are compared in the following table with the figures for pasture grass as previously stated and as given by Weiske, and with those given by Jordan for timothy hay "cut a couple of weeks past bloom."

Composition.

	Rye.	Clover.	Corn.	Pasture.		Timothy hay (Jordan).
				Armsby.	Weiske.	
Moisture	84.33	84.64	90.04	73.37	....	11.34
Water-free substance:						
Fat	4.89	5.27	3.98	6.24	5.09	3.01
Fiber	30.14	19.93	27.14	18.25	16.74	32.58
Nitrogen-free extract	40.51	37.32	39.32	44.39	42.09	53.48
Protein	15.99	22.29	17.28	21.89	27.07	6.70
Ash	8.47	15.19	12.28	9.23	9.01	4.23
Per cent of total nitrogen in non-albuminoid form	52.48	10.59	14.98	4.82	....	....

Digestibility.

	Rye.	Clover.	Corn.	Armsby.	Weiske.	Timothy hay (Jordan).
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Total dry matter	73.6	66.1	68.7	70.0	68.7	51.6
Fat	74.2	64.5	40.0	57.5	(*)	55.0
Fiber	79.6	52.6	74.7	75.5	67.3	42.8
Nitrogen-free extract	70.6	77.6	70.8	72.7	†76.8	58.9
Protein	79.1	67.0	78.1	68.8	77.4	45.2
True albuminoids	56.1	63.3	74.3	59.37	....	....
Ash	55.5	55.0	60.7	52.7	....	....
Nutritive ratio	1:4.8	1:3.2	1:3.7	1:3.7	1:2.5	1:16.4

*Stated with nitrogen-free extract.

†Includes fat.

Comparing the soiling crops with each other as regards composition, it is seen that the chief differences are in the content of protein and fiber, and that the crop containing the higher percentage of protein contains the less of fiber, for the crops in the order of richness in protein are clover, corn, and rye, but in the order of fiber content are rye, corn, and clover. * * *

Comparing these crops with pasture, it is observed that the latter, if it be of good quality, contains only a little more protein and fat than clover and less fiber and more nitrogen-free extract than either of the soiling crops. * * *

In general, it may be said that the pasture is slightly more digestible than the crops used for soiling purposes, and as a rule richer in nitrogen. * * *

Accepting Wolff's standard ratio for milch cattle, 1: 5.4, both the soiling crops and pasture are seen to furnish a greater proportion of nitrogen than is necessary; therefore, the wisdom of the usual practice of adding hay and grain of a medium ratio to milk rations is confirmed by the results of these experiments. * * *

[The author states in conclusion that] unless further investigation should disclose unfavorable dietetic effects, which there is now no reason to suspect, it may safely be concluded that, as far as the materials themselves are concerned, soiling crops are equally as valuable as pasture grass for milk production. * * * But before any conclusions can be reached concerning the comparative economy of soiling and pasture systems under given conditions, there are questions to be settled concerning the cost of producing and handling the crops.

Yield and nutritive value of soiling crops (pp. 95–105).—The soil on which this trial was made was "specially rich and heavily manured to obtain the greatest possible yield. * * * The soiling crops were cut twice per day, and the area cut was measured once in from 1 to 4 or 5 days, except in the case of the corn, of which only two measurements were taken. The soiling rye was from two different plats, of which the second was considerably the richer."

The total yield per acre and the yield of digestible food ingredients, as calculated from the tables given above, are given as follows:

Yield per acre.

	Total green food.	Total dry matter.	Digestible.			
			Albuminoids.	Non-albuminoids.*	Carbohydrates.	Fat.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Rye (average) †	15, 890	2, 491	106	209	1, 310	90
Clover	26, 650	4, 094	515	96	1, 614	139
Corn fodder	17, 890	1, 782	195	46	857	28

* Assumed to be wholly digestible.
† One plat yielded 13,770 pounds and the other 18,660 pounds of green rye per acre.

To test the nutritive value of these soiling crops they were fed separately, in connection with hay and grain, to seven cows. The grain consisted of bran and a mixture of about equal parts of corn and oats ground together.

The grain and hay were weighed out in advance in sufficient quantity to last for a number of days, and were fed to the cows in accordance with the judgment of the herdsman, he being instructed to feed as nearly as possible as he had been in the habit of doing in previous years. No attempt was made to ascertain the amount eaten by each individual cow. The amount of soiling fed was weighed twice daily immediately after cutting. The following table shows the [average] amounts of the several fodders actually eaten per day and head. The last portions of hay and grain weighed out for the rye period were more than sufficient to complete that period, and the residues were not weighed, but were simply carried over to the clover period; consequently the amounts of hay and grain eaten, as given in the table, are the average of these two periods, and may have varied somewhat in the single periods, although probably not very much.

Average food consumed per head daily.

Period.	Rye.	Clover.	Corn.	Grain mixture.	Bran.	Hay.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Preliminary	....	....	....	2. 07	1. 97	18. 47
I (May 16–June 4)	66. 19	....	....	2. 64	2. 40	5. 74
II (June 4–16)	....	69. 52	....			
III (July 24–August 15)	....	....	83. 89	2. 57	1. 67	5. 56

A summary follows of the milk and milk constituents produced per animal daily:

Yield per animal daily.

	Total milk.	Milk solids.	Milk fat.	Milk protein.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
Preliminary	14. 46	1. 84	. 60	. 44
Period I	14. 80	1. 93	. 64	. 46
Period II	14. 51	1. 89	. 63	. 42
Period III	13. 22	1. 68	. 60	. 41

The analyses of the milk for each period indicated that "in general the variations in the feeding had very little influence upon the composition of the milk." The amounts of dry and digestible matter required to produce 1 pound of milk or of butter were also nearly the same in the different periods. In view of these facts and the fact that the hay which furnished fully three-fourths of the digestible matter eaten in the preliminary period was largely replaced by the soiling crops in the other periods, the author believes that no particular advantage from the substitution of the soiling crops for hay is apparent, and that "the soiling crops were valuable in proportion to the amount of digestible matter which they furnished." Calculated on this basis and assuming the milk to contain 12 per cent of solids, the "product due to soiling" is found, and since the soiling for one cow for one day was supplied on the average by 181.5 square feet of rye, 113.6 square feet of clover, or 202.3 square feet of corn, the amounts of milk (with 12 per cent solids) and butter produced per acre for each soiling crop were found to be as follows:

Yield of milk and butter fat per acre.

	Milk.	Butter fat.
	Pounds.	*Pounds.*
Rye	2,120	84
Clover	3,098	125
Corn	1,508	65

Comparison of soiling crops and pasturage.—The above figures for soiling crops can not be compared directly with those for pasturage, "because of the three soiling crops we may grow either rye and corn or clover and corn on the same ground in one season." Taking account of this, the amount of milk and butter fat produced per acre with the soiling crops in a season is calculated to be 3,416 pounds of milk, or 139 pounds of butter fat.

The total product per acre of pasturage was, as previously stated, 710 pounds of digestible matter. The cows used in the soiling experiment "required on an average 0.7657 pound of digestible matter to make 1 pound of milk, and 18.9 pounds per pound of butter fat."

At this rate the 710 pounds of digestible matter furnished by the acre of pasture would produce 928 pounds of milk or 38 pounds of butter, so that the comparison with soiling crops stands as follows:

Product per acre.

	Milk.	Butter.
	Pounds.	*Pounds.*
Soiling	3,416	139
Pasturage	928	38
Difference	2,488	101

In conclusion, it can not be too emphatically stated that the figures and comparisons of the foregoing papers are only tentative and preliminary. No one spot of grass land can represent all pastures. No one season can represent all the varieties of climate. No single crop of soiling can show all the possibilities there are in the system.

GENERAL FERTILIZER EXPERIMENTS, W. H. CALDWELL, B. S. (pp. 106–124).—This is a report of progress on a series of experiments commenced in 1881. The experiment was on four tiers of 36 eighth-acre plats each, and had for its object a study of the effects of the different fertilizing ingredients, used singly and combined, and when applied in the form of barn-yard manure, with reference to permanency, total yield of crop, relation of parts of the plants, etc.

A four years' rotation of crops, consisting of corn, oats, wheat and grass, was adopted. The following shows the occupation of the land since 1881, it having been used for miscellaneous field experiments previous to that time:

Tier.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.
No. 1	Oats.	Wheat.	Grass.	Corn.	Oats.	Wheat.	Grass.	Corn.
No. 2	Corn.	Oats.	Wheat.	Grass.	Corn.	Oats.	Wheat.	Grass.
No. 3	....	Corn.	Oats.	Wheat.	Grass.	Corn.	Oats.	Wheat.
No. 4	....	....	Corn.	Oats.	Wheat.	Grass.	Corn.	Oats.

The commercial fertilizers were used in such quantities that wherever either of the mineral ingredients, potash and phosphoric acid, were applied, the same quantity per acre was given—48 and 100 pounds, respectively. Different groups of plats received nitrogen from each of the three different sources [dried blood, ammonium sulphate, and nitrate of soda] in quantities of 24, 48, and 72 pounds per acre. * * * The yard manure was the mixed product of the dairy and horse stables, and made from hay, corn fodder, soiling crops, corn, oats, and bran.

The yield of each plat in 1888 and the average gains on unfertilized plats are tabulated. As this is merely a report of progress and no conclusions are as yet drawn, a further discussion of the experiment is omitted.

COMPARATIVE VALUE OF DIFFERENT FORMS OF PHOSPHORIC ACID, H. P. ARMSBY, PH. D., AND W. H. CALDWELL, B. S. (pp. 124–134).—This is a continuation of previous experiments at the Station made "with a view to testing the relative effect of some of the various forms of phosphoric acid in actual crop production as compared with their cost in the market. The experiments were made upon the ordinary four-course rotation of this section, viz., wheat, grass, corn, and oats, the fertilizers being applied to the wheat and corn." Twelve twentieth-acre plats were used for the trial. To test their uniformity they were all seeded to oats in 1883, no fertilizers being applied to any of the plats. The results for 1883, as tabulated in this report, show "considerable irregularities in the yields of the individual plats." (For a summary for the first complete rotation of 4 years, see Annual Report of the Station for 1887, pp. 69–84.)

In 1888 wheat was grown on all the plats. Two of the plats had received no fertilizers since the beginning of the experiment. Of the ten remaining plats all received muriate of potash at the rate of 200 pounds and ammonium sulphate at the rate of 240 pounds per acre. While two plats received no other fertilizers, four pairs of plats received phosphatic fertilizers per acre as follows: 200 pounds of dissolved bone-black ("phosphoric acid largely soluble"), 200 pounds of bone-black previously treated with lime ("phosphoric acid largely reverted"), 150 pounds of fine ground bone, or 150 pounds ground South Carolina phosphate ("phosphoric acid largely insoluble").

It was, unfortunately, not possible to analyze the fertilizers in these experiments, but they are all standard articles of trade, and on the basis of the average composition of these articles, the quantities above used were computed to contain about 32 pounds of phosphoric acid in the case of the dissolved bone-black, the same reverted in the ground bone, and about 39 pounds in the case of the South Carolina phosphate. The plats receiving the phosphoric acid in the insoluble form were to this extent given an advantage over the others. It should be added, also, that ground bone contains more or less nitrogen, so that plats C and I received slightly more of this element than the others. With these two exceptions our four pairs of plats differ only in the form in which the phosphoric acid was applied.

The yield of wheat in 1888 is given as follows:

Yield of wheat per acre in 1888.

Plat.	Fertilizers used.	Yield of wheat.			
		Grain.	Straw.	Total.	Weight per bushel.
		Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
A	Potash, ammonia, and soluble phosphoric acid	1, 790	2, 410	4, 200	62. 5
B	Potash, ammonia, and reverted phosphoric acid	1, 670	3, 030	4, 700	63. 75
C	Potash, ammonia, and bone phosphoric acid	2, 065	3, 235	5, 300	60. 75
D	Potash, ammonia, and insoluble phosphoric acid	1, 960	3, 440	5, 400	61
E	Potash and ammonia	2, 125	2, 775	4, 900	60. 25
F	Unfertilized	1, 140	1, 260	2, 400	....
G	Potash, ammonia, and soluble phosphoric acid	1, 950	2, 450	4, 400	62. 75
H	Potash, ammonia, and reverted phosphoric acid	1, 750	2, 940	4, 700	63
I	Potash, ammonia, and bone phosphoric acid	2, 100	2, 900	5, 000	61
J	Potash, ammonia, and insoluble phosphoric acid	1, 860	2, 840	4, 700	61. 5
K	Potash and ammonia	2, 015	2, 685	4, 700	61. 75
L	Unfertilized	1, 280	1, 820	3, 700	....

"The above results show a large and unmistakable gain due to the use of fertilizers, as compared with the results on the plats remaining unmanured for five years."

The "gain due to phosphoric acid" is calculated by taking the difference between the yield with phosphoric acid, potash, and ammonia combined, and with potash and ammonia (plats E and K). The result of this calculation "is practically the same as that reported last year; no one form is clearly indicated as superior to the others." Summaries are given of the gains due to each of the different forms of phosphoric acid from 1884–88.

The general result to be deduced from these summaries, and in which apparently we may place some degree of confidence, is that, upon our soil, and under our conditions, bone gave the best results and soluble phosphoric acid the poorest, while the insoluble and reverted forms were intermediate in value, sometimes the one and sometimes the other of these two excelling. It is not impossible that a continuation of the experiment may result in assigning a relative value to the insoluble and reverted forms.

It is to be remembered that the bone contains some nitrogen and that some part of the effect here attributed to the phosphoric acid of the bone is really due to the nitrogen.

EXPERIMENTS ON THE PRODUCTION OF ROOT TUBERCLES, W. A. BUCKHOUT, M. S. (pp. 134–136).—The author makes the following report of his observations, commenced "some 5 years ago," concerning the root tubercles of various leguminous plants.

Starting with the garden pea, where these curious growths are conspicuous in size and number, they were found on other cultivated Papilionaceæ, also beans, sweet-peas, etc., and upon various wild species of *Vicia, Desmodium, Lespedeza,* etc. The examination of a considerable number of species of Leguminosæ led to the conclusion that they were produced upon the roots of all papilionaceous species, even trees and shrubs, but probably not upon those of *Cæsalpinieæ* or *Mimoseæ.* Of the latter, however, only a few examinations of *Gymnocladus dioicus* (Kentucky coffee tree), *Cercis canadensis* (redbud), and *Mimosa pudica* (sensitive plant) were made, and those not so fully as should have been done. Good material was hard to obtain.

In making microscopic examinations of the tubercles they were generally found to contain bacteria, but no attempt was made to determine whether they were the cause or merely accompaniments of the tuberculous growths.

[Procceding to a study of the conditions under which these bodies were formed], the garden pea was selected, and three kinds of cultures were undertaken, one in water, one in sand, and one in ordinary soil. Distilled water, rain-water, and hard water, respectively, were used for watering purposes. The pots containing the sand and soil to be watered with distilled water were subjected to prolonged baking in an oven previous to being used. The water cultures were carried on in short, wide-mouthed bottles, the seeds being supported on pieces of pumice or sandstone. In each case duplicates were taken to provide against loss or errors.

For convenience peas of the lowest and most compact growth were selected. The seeds were planted October 3 and kept in a cool greenhouse. Three examinations were made November 3, when the plants were about 3 inches high; December 29, when they were in flower; and the last, February 16, when they were in fruit. The 3-inch pots proved rather small, and the plants became somewhat pot-bound, but this probably did not affect the result as regards development of tubercles. * * *

The water cultures developed rather poorly, though some gave as vigorous and long-lived plants as any others.

It is evident that—

(1) No tubercles appeared in any of the water cultures.

(2) None appeared in either sand or soil watered with distilled water.

(3) They are more abundant from and after the time of flowering than before.

(4) There is no marked difference between the number occurring in clear sand and in soil.

HORTICULTURAL REPORT, G. C. BUTZ, M. S. (pp. 136–163).—The horticultural work of the Station is a new feature, and it is too early to draw conclusions from the data collated. "A large number of varieties have been grown side by side, with practically the same soil, treatment, and atmospheric conditions."

The soil of the Station garden is quite uniform, but not of that character which is most likely to promote vegetable growth. It has been cultivated many years previous for farm crops, with occasional light manurings; but being a cold, heavy clay, only a little darker than the subsoil, it will require several years heavy manuring and cultivation to bring it into a good condition for garden purposes. The land has a slight southeasterly slope, rising but little to the northwest, and there is no protection or wind-break in the immediate neighborhood of the garden.

Tabulated notes are given for 27 varieties of bush-beans, 20 of pole beans, 13 of beets, 8 of carrots, 27 of early and 7 of late cabbages, 3 of cauliflowers, 16 of cucumbers, 24 of sweet-corn, 21 of lettuce, 30 of peas, 31 of radishes, and 29 of tomatoes. There are also tabulated and descriptive notes on 22 species of weeds.

Grapes (pp. 158–161).—"On the college grounds is a vineyard of 450 vines, most of which were planted about 15 years ago. The location is almost level, with our characteristic limestone soil. The vines are trained to trellises running northwest and southeast, in order to be parallel with some established lines."

The practice of pinching off the heads of the young shoots which have grown four or five joints beyond the bunches of young fruit, and of cutting out weak, fruitless sprouts once a week during June and July, was followed in the vineyard in 1888, "and an excellent crop of fruit was gathered from the vines—bunches full, heavily shouldered, large, and with immense berries. One of these fine bunches of Concord weighed slightly over 1 pound."

Sulphate of copper solution, Bordeaux mixture, modified eau celeste and flowers of sulphur were used as fungicides for black rot and mildew, but the attacks of these diseases were so slight in 1888 that the tests were inconclusive. Brief notes are given on 10 varieties of grapes planted in 1886, and on 5 varieties planted in 1888.

Orchard fruits (p. 161).—"The old orchard on the college grounds contains some 450 trees that were principally planted about 1860, but no record of the early planting can be found. Including some recently planted young trees there are represented about 40 varieties of apples in this orchard, besides a few others that have not yet been identified." A list is given of 25 varieties of pears, 22 of plums, 5 of quinces, and 3 of apricots planted in 1886.

Phenological observations (pp. 162, 163).

The influence of climate on vegetation is strikingly illustrated in a record of the dates when the first foliage, flowers, and fruits appeared upon plants and trees growing in the same locality. Much vegetative action in the spring is due to heat and moisture only, no nourishment from the soil being needed. A simple and interesting experiment on this point, is the following: A few dormant twigs of flowering wood cut from a bush of *Forsythia viridissima* on the 30th of January, were put into a vase that the ends might be kept in water, and the vase thus arranged was placed in a room of about 62° Fah. In one week's time the buds had pushed out of the inclosing scales and a few days later the twigs were literally a mass of yellow bell-like corollas. The experiment might be tried in December, with equal results, and distilled water may be used if it is thought some nourishment is extracted from ordinary water.

Phenological notes are of service to such persons as are contemplating the planting of ornamental or shade trees; for while a catalpa, for example, is known to be a

> rapid grower, has large leaves, and makes a healthy shade, yet when it is found, as shown in the notes of the table, that the catalpa does not come into leaf until the 28th of May, when other trees have long been affording a heavy shade, we then have a serious objection to planting such a tree for such a purpose.
>
> Such observations are of great service to the forester, also, particularly if they are taken at numerous points over the country, in order to note the capacity of a species for acclimatization.

The tables given in the report include the common and scientific names, date of first leaf, first flower, ripe fruit, and whether native or cultivated, for 24 species of trees, 16 of shrubs, and 12 of herbs.

AN EXPERIMENT IN FORESTRY, W. A. BUCKHOUT, M. S. (164–166).—The importance of experiments in forestry by the Station is urged. "Pennsylvania has been one of the well-wooded States; moreover she still furnishes large quantities of wood materials, and has large areas which support forest growth. The forests are gradually disappearing, and in large part the land which they occupied is fit for nothing except a new tree growth. Natural replacement is often unsatisfactory in that the varieties of trees which appear spontaneously are not the best, their growth is not uniform, and there is great difficulty in protecting them."

With a view to studying the forest problem, as presented in that vicinity, which is a good type of the mountainous region of the State, the Station has secured "the use of a small piece of land on the southeast side of Tussey Mountain, which is a fair average of mountain land, and is just such as must be used if in the future there should be any extensive forest planting over our mountainous districts. Cut over some 40 years ago for charcoal it has since grown up to a mixed growth of chestnut, pitch-pine, and various shrubby species, all of which has been subject to periodical fires, so that the growth is thin and unequal. No preparation was given except to cut off and burn all the brush.

"The trees planted were chestnut and white pine (the former being about 6 to 8 inches high with very prominent tap-roots, and the latter rather larger, averaging 10 inches), and trees which had been once transplanted. They were set about 5 feet apart by digging small holes with a mattock, and no extra pains were taken with them."

The sowing of white pine, white birch, and locust seeds has also been tried on a small scale, and this work has been duplicated on the cultivated soil of the college farm.

RELATION OF METEOROLOGICAL CONDITIONS TO THE DEVELOPMENT OF CORN, W. FREAR, PH. D., AND W. H. CALDWELL, B. S. (pp. 167–170).

> The predominant natural influence affecting the growth of a crop in any locality is that of climate. This is far more influential than fertility of soil, though there is a certain minimum of that essential to plant life; but it is a matter of common observation that with exceptionally favorable climatic conditions fine crops may be grown on comparatively infertile soils. Each plant has its own most favorable climate. It is a marked property of cultivated plants, as compared with the wild species or varieties, that they may be grown successfully under ranges of climatic

condition wider than those well adapted to the original, uncultivated species. But a change of climatic surrounding is generally accompanied by a variation in proportional development of the plant.

The maize plant, with its wide range of territory, has a corresponding range of variation in its variety types—from the tall, large-eared, but very leafy dents of the South, to the low, small-eared, but abundant grain-producing flints of the North. Notwithstanding this exceptional power of adaptation to surrounding conditions, the maize crop is as much influenced in development by the seasonal variations as any crop we cultivate. In other words, the conditions favorable to the best development are fixed within a narrow range for any varieties adapted by long culture to the general climate of a given locality. It is a well-known fact that with all its adaptability corn can not be brought to maturity in England with the cool, moist, cloudy summers prevalent there, and it is believed that the heat of American summers, even in the higher latitudes, is the special climatic feature that makes the culture of this valuable plant possible over so extended an area, reaching from Central America to Canada.

As was stated last year, the knowledge we possess concerning the effects of the several elements which unite to form our climate, lacks definiteness, and the results of a series of observations upon the rate of growth of corn were compared with the meteorological observations carried on at the same time, with the hope that careful comparison might bring out into greater prominence those elements producing the most favorable influence upon our varieties of that crop.

This year the observations were continued, the seed being an acclimated yellow dent, and the same method of measurement being followed. Six plants were selected and the increase in height noted at intervals of several days. For this purpose, the tip of each new pair of leaves was used as the point of departure for the days immediately succeeding its appearance. From the figures obtained an average was struck which was assumed to represent the actual growth for the interval, and by dividing by the number of days intervening the daily rate of growth was obtained. It was hoped that in this manner errors in measurement arising from the appearance of new modes of growth would be distributed over the different plants and thus eliminated. This method can not take into account the variation in the rate of growth due to climatic changes as distinguished from those due to the development of the special organs of the plant (at ears and tassel), nor to the less noticeable, but no less present, difference in the rate of growth caused by a difference in the stage of maturity; it assumes also that increase in material in the plant, which is doubtless the best measure of its growth, is accompanied by a proportional development of plant organs. All that is claimed for it is that it serves quite well for comparative purposes, even though it does not give results that are absolutely correct.

The following remarks upon the development of the plant will be of interest: May 8, six hills of corn, 1½ feet apart, three kernels to the hill, were planted in the garden and covered to a depth of 1½ inches. The spot was slightly shaded in the afternoon. The corn was up in all the hills on May 22. From this day to June 18, the number of plants having been reduced to one in each hill, measurements were taken, but from mistake by the wrong method; on June 18, when the plants were 8 to 12 inches high, the method above mentioned was returned to, and measurements were continued until August 22, although no increase in height was noted after the 8th. The plants were cultivated last on July 23. One tasseled on July 13, two more on the 19th, two more on the 23d, and the last on July 31, by which time ears showed on the three that tasseled first. The position for growth was not quite so favorable as in 1887, though there was no difference between the six hills in this respect.

In the following table will be found a statement of the mean intervals of growth of the six stalks:

	Inches.		Inches.		Inches.		Inches.
June 19	1.6	July 3	2.3	July 17	2.5	July 31	1.7
20	1.6	4	2.7	18	2	Aug. 1	1.9
21	1.5	5	3	19	2.6	2	1
22	1.9	6	2.3	20	2	3	1.2
23	1.9	7	2.7	21	2.7	4	0.9
24	2.5	8	2	22	3.6	5	0.6
25	2.9	9	2.3	23	4.1	6	0.1
26	2.4	10	1.9	24	4.7	7	0
27	1.9	11	3	25	3.1	8	0.2
28	1.3	12	2.3	26	3.5	9	0
29	1.1	13	1.5	27	4.3	10	0
30	1.5	14	1.5	28	2.9	11	0
July 1	2.3	15	2.1	29	1.6	12	0
2	1.6	16	2	30	2		

In order to show more clearly the relations existing between the observed rate of development and the meteorological conditions, variation of the growth of corn and principal meteorological conditions for 1888 were plotted on a diagram, which is published in the report. The data included (1) the mean daily rate of growth, (2) the mean daily atmospheric temperature, (3) the mean daily soil temperature at 3 inches depth, (4) the mean daily humidity, (5) the mean daily rate of evaporation, (6) the daily rain-fall.

A study of the diagram in 1887 shows that the temperature was the controlling element among the meteorological conditions of that year. The corn was planted May 12, and reached its average maximum height of 80 inches by July 23, a period of 72 days, during which there was a mean daily temperature of 70 degrees, a precipitation of 8.3 inches, 31 days on which more than 0.01 inch of rain fell, and a mean daily cloudiness of 4.2 on a scale of 10.

In 1888 the corn was planted May 8, and attained its average maximum height of 81 inches on August 8, an interval of 92 days, during which there was a mean daily temperature of 67 degrees; a precipitation of 11.5 inches, falling on 28 days, of which 13 occurred before June 1; and a mean daily cloudiness of 4.9 on a scale of 10. Under these conditions the influence of variations in the temperature seems predominant, in such a degree, indeed, that variation in the other conditions within their observed ranges were productive of no measurable influence upon the rate of growth, unless it be that the rain-falls of June 21 and 23, and that of July 20, may account for the slight increase in the rate of growth, as compared with that which would theoretically have obtained had the line of increase followed the lines of variation in atmospheric and soil temperature as closely as usual.

Professor C. S. Plumb made certain, somewhat similar, observations during 1886, at the New York State Station, the results of which were published in Agricultural Science, Vol. III, p. 1. Beginning with May 21, the date of planting, the last seven plants completed their growth in height by August 1, but the principal growth was complete by July 25, a period of 65 days, during which there was an average air temperature of 59 degrees; an average soil temperature at 2 p. m. and at 3-inch depth, of 72 degrees; a rain-fall of 7.53 inches; and a sunshine of about 6.5 hours average daily duration. The soil was quite uniform, unmanured, fairly moist, and kept fairly free from weeds by hand cultivation. His results did not show the same close correspondence between temperature variation and rate of growth, but here too the principal factor in production of variation, leaving out of account the effect of the development of special organs at the proper stage of growth, seemed to be temperature, with probably a somewhat large influence, due to rain-fall. It is difficult, owing to a difference in the method of measurement, to make any close comparison of Professor Plumb's results with those obtained by the method employed at this Station. The results are cited rather for the sake of a comparison of final measurements and average climatic condition.

METEOROLOGY, W. FREAR, PH. D. (pp. 170–189, and 197–242).

The work of the past year has been chiefly a continuation of the work of the preceding years, including observations of the kind usually made by the U. S. Signal Service upon atmospheric phenomena, and also observations upon soil temperature at various depths, the amount of sunshine, and the soil moisture.

The results of the observations upon atmospheric phenomena have been reported regularly to the Chief Signal Officer, U. S. Army, and to the State weather service, and weekly crop reports have also been sent to the State service.

Atmospheric meteorology.—The latitude of the Station is about 40° 55′, and the longitude about 77° 51′. The altitude of the superintendent's house, where the meteorological instruments were placed, is about 1,185 feet above sea level, the elevation of the barometer's mercury level being 1,191 feet.

The apparatus used consists of a standard mercurial barometer reading to $\frac{1}{100}$ inch, dry and wet bulb, and maximum and minimum thermometers by Green, in addition to a standard 3-inch rain-gauge and an anemometer.

The thermometer shelter was placed against the northeast end of the house, at a height of about 25 feet from the ground.

The observations up to June 1 were in immediate charge of Mr. H. J. Patterson, now chemist to the Maryland Agricultural Experiment Station; after that date they were made by Miss Blanche Patterson. * * *

Sunshine records.—The importance of sunshine in plant development needs no comment. The method adopted by the U. S. Signal Service of recording the per cent of cloudiness at 7 a. m., 2 p. m., and 9 p. m., affords only a moderate approximation to the real degree of sunshine; it is therefore desirable to determine more closely the amount of sunshine received by the vegetation of this locality. This was done by means of the apparatus described in last year's report, by which the image of the sun as it travels about a spherical reflector traces a corresponding arc of a circle upon a sensitized paper placed in a camera focused upon the image in the reflector; any break in the sunshine causes a break of similar duration in the photographed path of the sun's image around the sphere. By this method it is possible to get a record only of the duration of sun's length, and not of the relative intensity.

The observations were in charge of Mr. W. H. Caldwell; the computation from the fixed photographs were made by Miss Blanche Patterson. * * *

Soil temperatures.—Observations upon soil temperature have been made in part with the hope of adding something to the knowledge we already possess concerning the climatic conditions of the soil, but more directly for the bearing they have upon the field investigations in progress. These observations are in continuation of those made last year.

The observations were made tri-daily at the same time with the observations upon air temperature. The thermometers were made by Green according to his pattern, and were carefully set in niches cut in a trench, the earth being afterward carefully tamped about the bulb so as to secure a good contact, the trench being filled at the same time. The surrounding surface was freed from vegetation and kept loose by stirring from time to time. The surrounding soil was covered with sod. The depths at which observations were made were, at the surface, 1, 3, 6, 12, and 24 inches. The soil was a moderately dark, compact loam for a depth of about 7 inches, and after that, a stiff clay subsoil. The rocks, judging from neighboring excavations, were 5 to 7 feet below the surface.

Soil moisture.—Water acts upon the plant not only as a food far more abundantly consumed than any mineral ingredient of the soil, but also as the medium by means of which the stores of other food in the soil are conveyed to the plant and diffused through it. Experimenters in the field are too often forced to reject results because of differences in moisture of the plats upon which their crops are grown, differences so slight as to be scarcely visible to the eye, but showing clearly in the character of the growth obtained.

An attempt has therefore been made during the past year to keep track from week to week of the variations in the moisture of the soil of the Station farm. For this purpose a smooth piece of sod was selected and sampled every week by driving an iron tube, 1½ inches in diameter, into the soil to a depth of 6 inches and then withdrawing it, taking out the soil from within the tube and making a moisture determination. This determination was not an absolute one, but only a determination of loss by air-drying, although great care has been exerted to maintain the conditions of this operation quite constant. The soil is a moderately heavy loam, usually quite a good deal "heaved" by frost, and having scattered through it large numbers of small pieces of flint, which are continually working to the surface. The mechanical condition is usually good and open, and the whole soil is naturally underdrained by the porous limestone upon which it lies.

Mr. G. L. Holter had immediate charge of these observations, the results of which are presented in the following table:

Soil moistures.

Date.	Intervening rain-fall.	Days since last rain.	Loss in air-drying.	Date.	Intervening rain-fall.	Days since last rain.	Loss in air-drying.
	Inches.		*Per cent.*		*Inches.*		*Per cent.*
April 30[*]	....	10	31.5	Aug. 6	0.52	1	14.0
May 8	.54	3	38.0	13	1.57	1	45.0
14	2.19	0	40.0	20	0.37	3	33.0
21	1.09	3	38.5	27	2.47	6	46.0
28	1.23	2	39.5	Sept. 3	1.23	3	52.0
June 3	1.61	1	33.0	10	1.21	2	50.0
11	0.27	0	33.5	17	0.94	0	[†]55.0
18	.00	8	17.0	20	0.97	0	[†]63.0
July 2	2.04	6	38.0	Oct. 15	1.78	2	41.0
10	1.00	0	42.0	22	1.35	3	29.0
16	0.75	4	32.0	30	0.63	2	51.0
23	0.96	4	38.0	Nov. 5	0.15	2	40.0
30	0.07	3	20.0	12	0.89	2	35.0

[*] Dry weather for 10 days before.

[†] After a driving shower.

Monthly summaries of the meteorological observations and weekly crop reports are given in the body of the report and the detailed record of daily observations in the appendix. The weather signals of the U. S. Signal Service are illustrated by colored diagrams.

Notes on the meteorology of 1888.—To represent still more compactly the seasons of 1888 in their relation to agriculture, a summary is presented below of those data most important, from an agricultural point of view, grouped so as to show the totals for January to December, 1888, and also the winter of 1887–88 (October to March), and the growing season of 1888 (April to September); and to this are added a few of the most important notes on the growing seasons, as indicated by the development of the crops of the year.

Summary of meteorological observations.

	Year 1888.	Winter (October, 1887, to March, 1888).*	Growing season (April to September, 1888).
Barometer:	*Inches.*		
Mean	30.06		
Highest	30.97 (Feb. 15)		
Lowest	29.00 (July 18)		
Temperature:	° *Fah.*	° *Fah.*	° *Fah.*
Mean	46.58	32.78	61.68
Highest	95 (June 21)	....	95 (June 21)
Lowest	−13 (Feb. 10)	−13 (Feb. 10)	20 (April)
Annual range	108		
Mean daily range	18.14	....	21.13
Greatest daily range	40.5 (Feb. 15)	....	37 (April)
Least daily range	3 (Aug. 21)		
	Per cent.		*Per cent.*
Mean daily relative humidity	71.81	....	72.94
Rain-fall:	*Inches.*	*Inches.*	*Inches.*
Total	40.62	12.21	23.7
Greatest monthly	6.26 (May)		
Least monthly	1.70 (Feb.)		
Greatest daily	2.47 (Aug. 21)	....	2.47 (Aug. 21)
Number of days on which 0.01 inch or more rain fell	127	*25	50
Mean percentage of cloudiness	56.34	....	47.96
Number of days on which cloudiness averaged 80 per cent or more	131	84	46
Wind:	*Miles.*		
Total movement	20,210.9		
Maximum velocity	34.8 (Jan. 26)		
Greatest daily movement	372.4 (Dec. 18)		
Last frost in spring	....	....	April 13
First frost in fall	....	....	Sept. 12

* Number of days on which snow fell.

Soil temperatures April to September, 1888.

	At surface.	Below surface.				
		One inch.	Three inches.	Six inches.	Twelve inches.	Twenty-four inches.
	° *Fah.*	° *Fah.*	° *Fah.*	° *Fah.*	° *Fah.*	° *Fah.*
Highest temperature.	97 (June 21)	88 (June 15)	82 (June 15)	77.75 (June 18)	78.50 (Aug. 17)	68.50 (Aug. 9 and 10)
Lowest temperature.	31 (Apr. 7)	32.25 (Apr. 9)	34.25 (Apr. 8)	36.50 (Apr. 22)	39 (Apr. 22)	38.75 (Apr. 5)
Mean daily range.	20.59	9.86	7.62	4.55	1.54	0.45
Greatest daily range.	40 (Apr. 28)	25.25 (Apr. 9)	20 (May 4 and 6)	11 (Apr. 27 and Sept. 7)	11.5 (Aug. 16)	4.75 (Aug. 5)

Principal periods of crop development.

Wheat:
- Headed June 8.
- Ripened July 6.
- Harvested July 13 to 20.

Hay:
- Ready to cut June 22.
- Harvest ended July 13.

Oats:
- Sown April 27.
- Earlier varieties ripening July 6.
- Harvested August 3 to 17.

Corn:
- Sown May 18.
- Cut September 21 to October 5.

The winter was not most favorable to grain, since the snow, although falling frequently, was badly drifted and the hills laid bare; there was therefore considerable loss by winter-killing. The spring was late and wet, plowing and planting being retarded and vegetation advancing slowly; many seeds germinated badly, vegetables, especially, rotting. The weather changed during June to September, the rain-fall being badly distributed, and vegetation was retarded by lack of warmth and sunshine; for only a short period the soil seemed deficient in moisture. All early harvests but that of wheat were completed in excellent weather. The later season was cold, damp, and cloudy, interfering with the ripening of corn and potatoes, making the harvest of the latter difficult and injuring the corn stover greatly during field curing.

The report also contains directions for taking and sending samples of fodders, dairy products, seeds, plants, and insects; a list of exchanges received by the Station; and a photo-engraving showing the office and laboratory building and the farm buildings of the Station.

RHODE ISLAND.

Rhode Island State Agricultural Experiment Station.

Department of Rhode Island State Agricultural School.

Location, Kingston. Director, C. O. Flagg, B. S.

FIRST ANNUAL REPORT, 1888.

Report of Board of Managers (pp. 3–27).—This is for both the school and Station, and includes brief statements regarding the history of education and investigation in agriculture in the United States, especially in Rhode Island, the organization of the school and Station, and the equipment of the Station. The report is accompanied by a map of the Station farm.

SOUTH CAROLINA.

South Carolina Agricultural Experiment Station.

Department of the University of South Carolina.

Location, Columbia. Director, John M. McBryde, Ph. D., LL. D.

FIRST ANNUAL REPORT, 1888.

Part II.

[A digest of Part I of this report was published in Part I of this bulletin, pp. 175–182.]

Field experiments, J. M. McBryde, Ph. D. (pp. 143–291).—These experiments with oats, wheat, corn, and cotton were carried on at the experimental farms at Columbia, Spartanburg, and Darlington, and "were undertaken for the purpose of ascertaining, if possible (1) the requirements of the soils of our three experimental farms; (2) the requirements of our leading crops; and (3) the relative values of different kinds of nitrogenous, phosphatic, and potassic manures."

> All of the soils operated upon were typical ones. * * * The Spartanburg, or upper farm, is made up of different detached bodies of land, differing materially from one another in character. All contain considerable percentages of clay. The subsoil is clay.
>
> The soil of the Columbia farm is almost a pure sand throughout. No clay is found within 20 feet of the surface. The surface soil of the Darlington farm is sandy—the subsoil has some clay.
>
> [The soils of all were] worn out by years of improvident tillage.

Experiments with oats (pp. 144–156).—These include tests of fertilizers, varieties, and method of seeding made at the Darlington and Spartanburg farms.

1. *Special nitrogen experiments.*—These were made to test the comparative value of "some of the nitrogenous fertilizers used by our farmers."

At Darlington "6 acres of the poorest land on the farm were divided into half-acre plats. Each plat was much longer than broad. The soil was apparently a sterile sand, with here and there a few tufts of worthless grasses (*Eragrostis capillaris*, *Andropogon scoparius*, etc.). Every test was carefully duplicated, each plat being separated from its duplicate by the width of five intervening plats. * * * The tests were made for the purpose of determining the relative values of organic and inorganic forms of nitrogen, and a mixture of the two," the organic nitrogen being furnished in the form of cotton seed or cotton-seed meal and the inorganic nitrogen as nitrate of soda. Potash as muriate and phosphoric acid as acid phosphate were used in all cases.

The full calculated amounts of nitrogen, phosphoric acid, and potash (52 pounds, 19 pounds, and 38 pounds, respectively) contained in the straw and grain of a crop of 45 bushels of oats per acre, were applied on six plats, the nitrogen being supplied in two cases by cotton-seed meal and nitrate of soda combined (1), in two others by nitrate of soda (2), and in the remaining two as cotton-seed (3). On four plats the full amounts of phosphoric acid and potash were applied and half the amount of nitrogen, the latter being supplied in two cases as nitrate of soda (4), and in the other two as cotton-seed meal (5). Two plats (6) received no fertilizers of any description. The average yields of the duplicate plats were as follows:

Yield per acre and financial results (Darlington).

Plat.	Forms of nitrogen.	Average yield per acre of duplicates.				Pounds of straw to 1 pound of grain.	Cost of fertilizers.	Value of increase in grain with fertilizers.	Profit (+) or loss (—) with fertilizers.
		Straw.	Grain.	Total produce.	Bushels of grain (32 pounds).				
		Lbs.	*Lbs.*	*Lbs.*	*Bush.*				
1	Organic nitrogen 18 lbs.. } Inorganic nitrogen 34 lbs. } 52 lbs.	955	846	1,801	26.45	1.13	$10.08	$9.34	—$0.74
2	Inorganic nitrogen ....do..	939	835	1,774	25.99	1.12	10.61	9.10	— 1.58
3	Organic nitrogen ....do..	893	714	1,607	22.32	1.25	12.12	7.27	— 4.85
4	Inorganic nitrogen.........26 lbs.	791	771	1,562	24, 10	1.02	6.56	8.16	+ 1.60
5	Organic nitrogen 18 lbs.. } Inorganic nitrogen 8 lbs. } ..do..	573	528	1,101	16.50	1.09	6.03	4.36	— 1.67
6	Unfertilized	294	259	553	7.78	1.13	......	....	....

It is clear, from a comparison of the average yields of the fertilized and unfertilized plats, that the several applications largely increased the crops. Fifty-two pounds of nitrogen in (1), (2), and (3), and 26 pounds of nitrogen in (4) more than tripled the yield, and 26 pounds of nitrogen in (5) more than doubled it. Upon comparing the different forms of nitrogen in (1), (2), and (3) it appears, after allowing for probable error, that all gave practically the same yield. But where the nitrogen was reduced one-half in (4) and (5), the phosphoric acid and potash remaining the same, the results are clearly in favor of the inorganic form (4). Proceeding next to consider the question of the proper amount of nitrogen per acre, we find, upon comparing (4) with (1), (2), and (3), that the amount used in the three last (52 pounds per acre) was excessive, and that one-half this amount gave equally good results. Fifty-two pounds appear, however, to have increased the yield of straw. Upon a careful comparison of all the results it would seem that the inorganic form gave somewhat the best results and the organic the worst. For it should be noted that in (1) the nitrogen was largely in the inorganic form (34 pounds of inorganic to 18 pounds of organic), and that in (5), where the amount of organic nitrogen was the same as in (1), but the inorganic was reduced to 8 pounds, the yield was correspondingly reduced. And 52 pounds of organic nitrogen in (3) hardly equaled (in yield) 26 pounds of inorganic in (4).

In calculating the value of the increased yield with fertilizers no account was taken of the straw, and the grain was valued at 50 cents per bushel (32 pounds). "Oat straw, however, has considerable nutritive value and the fertilizers largely increased its yield. When due allowance is made for this increase all the applications except (3) will show some profit, and (4) quite a fair one."

At Spartanburg the plats were each 1 acre in size, and the tests were not duplicated. Fertilizers were applied as follows:

Fertilizers used per acre (Spartanburg).

Plat.	Eutaw ammoniated guano.	Nitrate of soda.	Cotton-seed meal.	Cotton seed.	Kainit.
	Pounds.	*Pounds.*	*Pounds.*	*Bushels.*	*Pounds.*
1	200	300	....	....	250
2	140	175	300	....	250
3	....	....	....	64	100
4	....	....	....	32	100

The source of nitrogen in the Eutaw guano was not known, but as the 200 pounds used only furnished 3.3 pounds nitrogen, it was assumed to be, along with the 48 pounds in the nitrate of soda, inorganic.

The yields of the several plats, the cost of fertilizers, the value of the increased yield of grain, and the profit or loss resulting from the use of fertilizers were as follows:

Yield per acre and financial results (Spartanburg).

Plat.	Form of nitrogen.	Yield per acre.				Pounds of straw to 1 pound of grain.	Cost of fertilizers.	Value of increase in grain with fertilizers.	Profit (+) or loss (—) with fertilizers.
		Straw.	Grain.	Total produce.	Bushels of grain (32 pounds).				
		Lbs.	*Lbs.*	*Lbs.*	*Bush.*				
1	Inorganic nitrogen.......52 lbs..	1,350	1,050	2,400	38.81	1.28	$10.30	$15.19	+$4.98
2	Organic nitrogen 22 lbs.. Inorganic nitrogen 30 lbs do....	1,006	760	1,766	23.75	1.32	10.43	7.66	— 2.77
3	Organic nitrogen ....do....	999	630	1,629	19.69	1.58	12.12	5.63	— 6.49
4	Organic nitrogen.........26 lbs..	926	600	1,526	18.75	1.54	6.36	5.16	— 1.20
5	Unfertilized......................	418	270	688	8.43	1.54	......	....	....

> Here again every application shows a marked increase in the yield, (1) more than quadrupled the crop, (2) nearly trebled it, and (3) and (4) more than doubled it. The differences in the yields afforded by the several forms of nitrogen were far more pronounced than at Darlington. The inorganic forms gave 15 bushels more than a mixture of the inorganic and organic and 19 bushels more than the organic. And, as compared with the unfertilized acre, it shows a gain of 30.38 bushels. Here again, as will appear upon comparing (4) with (3), 26 pounds of nitrogen gave equally as good results as 52 pounds. It should be added also that (4) contained only one-half as much phosphoric acid and two-thirds as much potash as (3).

With regard to the financial results, " adding in the value of increase in straw will show a handsome profit for (1), a very slight profit for (2) and (4), and a loss for (3).

"The results of the Spartanburg tests were decidedly favorable to the inorganic form of nitrogen."

Considering both experiments the author concludes that—

> The results thus far would seem to indicate, first, that nitrate of soda is perhaps a more profitable source of nitrogen for this crop than cotton seed or cotton-seed meal; and, second, that moderate applications of nitrogen are equally as effective as heavy ones, or to state the last point differently, that it is only necessary to return to the soil one-half the quantity of nitrogen contained in the oat crop.

2. *Special phosphoric acid experiments.*—Experiments were made at Darlington and at Spartanburg to test the comparative value of "floats" and Thomas slag. In each experiment 300 pounds of floats, containing 26.60 per cent phosphoric acid, and 300 pounds of Thomas slag, containing 21.46 per cent phosphoric acid, were each used on one plat. The cost of the slag was $1.72 and of the floats $1.50 per acre. In the experiment at Darlington 100 pounds of nitrate of soda per acre were applied as a top-dressing. The yields in the two experiments were as follows:

Kind of fertilizer.	Yield per acre.				Pounds of straw to 1 pound of grain.
	Straw.	Grain.	Total produce.	Grain in bushels.	
	Pounds.	*Pounds.*	*Pounds.*	*Bushels.*	
Darlington:					
Thomas basic slag ....300 pounds..	340	380	720	11.87	0.89
Floats ....do....	332	312	644	9.75	1.06
Spartanburg:					
Thomas basic slag......................do....	1,240	650	1,890	20.31	1.90
Floats ....do....	1,040	600	1,640	18.75	1.73

In both cases "the slag shows a slight but steady superiority."

3. *Test of varieties of oats.*—This is a duplicate test of Red Rust-Proof, Georgia Grazing, Black Russian, Wide-Awake, and Badger Queen oats, made on twentieth-acre plats at Spartanburg. Fertilizers sufficient for a crop of 70 bushels of oats per acre were applied to the soil.

> The two plats of Red Rust-Proof gave the largest average yield of grain per acre, 35 bushels. This variety is very generally and justly esteemed as the best for our State and section. The Georgia Grazing gave almost the same total produce, 120 pounds more straw, and 80 pounds less grain. This kind is largely grown in some

of our upper counties. The remaining three kinds were Western varieties * * * [Black Russian] gave less of grain and straw than both of our home-grown varieties The Wide-Awake gave about 8 bushels less and the Badger Queen about 12 bushels less than the Red Rust-Proof. With every allowance for probable error, the yields of these two kinds are unmistakably inferior to those of the two Southern varieties. The Badger Queen gave nearly the same weight of grain as straw, the proportion being 1 to 1.28.

4. *Methods of seeding oats.*—The following experiment was made at Spartanburg on six 1-acre plats, all but one of which received 125 pounds acid phosphate, 100 pounds cotton-seed meal, and 75 pounds kainit per plat. All the plats were seeded February 2 or 3, 1888. The methods of preparing and seeding the land, and the yields were as as follows:

Preparation, seeding, and yields.

Plat.	Modes of preparation and seeding.	Yield per acre.				Pounds of straw to 1 pound of grain.
		Straw.	Grain.	Total produce.	Grain in bushels.	
		Pounds.	*Pounds.*	*Pounds.*	*Bushels.*	
1	Plowed with a turn plow, harrowed, and rolled; seed drilled in with a grain drill and again rolled	760	380	1,140	11.87	2.00
2	Plowed with a turn plow. Oats broadcasted and put in with a shovel plow	700	359½	1,059½	11.23	1.94
3	Plowed with a shovel plow (ridged). Oats broadcasted, harrowed, and rolled	702	343	1,045	10.62	2.04
4	No preparation. Oats broadcasted and plowed in with a shovel-plow	700	327	1,027	10.22	2.14
5	Ridged. Oats broadcasted, harrowed, and rolled	624	306	930	9.56	2.04
6	Unfertilized	380	131½	511½	4.11	2.89

"An application of 300 pounds per acre of mixed fertilizers increased the crop from 200 to 300 per cent."

Wheat (pp. 156–161).—The following experiments with wheat were made at the Spartanburg farm; they include tests of fertilizers and varieties.

1. *Fertilizers on wheat.*—The land used for this experiment adjoined that used in the fertilizer experiments with oats, and "on account of its poverty and in order to try the effects of very heavy manuring, amounts of potash, phosphoric acid, and nitrogen, sufficient for a crop of about 50 bushels of grain per acre, were applied." These, in the form of nitrate of soda, muriate of potash, and acid phosphate, were used singly, two by two, all three combined, and the latter combined with cotton-seed meal, on twentieth-acre plats, all the tests except two being duplicated. Two plats received no fertilizer.

In spite of the poverty and poor condition of the soil, the wheat in a number of the fertilized plats promised a very heavy yield. Unfortunately, however, the rust appeared just before harvest, and seriously injured the crop. * * * There was remarkably close agreement between the yields of the duplicate plats of each test, * * * the average difference between the duplicates being about one-half bushel of grain per acre.

The table of average yields of the duplicate plats shows the yield of grain to have ranged from 2.16 bushels to 14.33 bushels per acre, the smallest yield being on the unfertilized plats, and the largest with the combination of muriate of potash, acid phosphate, nitrate of soda, and cotton-seed meal (No. 10). The smallest yields where fertilizers were used were with nitrate of soda and muriate of potash, the yield being in the case of each 2.33 bushels per acre.

> (1) The separate applications of the three fertilizers were valueless. Nitrate of soda in (2) and muriate of potash in (3) produced no effect whatever upon the yield of grain, and but very little upon the straw. Acid phosphate in (3) considerably improved the crop of straw and slightly increased the yield of grain. The land was evidently deficient in more than one element of fertility.
>
> (2) The potash, alone or in combination with nitrogen, was of slight value. Combined with phosphoric acid, it seems to have been of some little benefit to the crop. * * *
>
> (3) Nitrogen when used alone was of no benefit to the crop; in combination, especially with phosphoric acid, it greatly improved it. * * * Combined with phosphoric acid it largely increased the yield of grain and straw. * * * [Where] the same amounts of nitrogen, phosphoric acid, and potash were used as in the other tests, but the nitrogen was partly in the organic and partly in the inorganic form, the application increased the crop very nearly seven-fold. It would seem to follow, therefore, that when used upon wheat in early fall, a mixture of organic and inorganic nitrogen is better than applications of inorganic nitrogen applied in the spring. The soil was so thin that some nitrogen was needed to carry the wheat through the winter.
>
> (4) Phosphoric acid gave the most pronounced results of all and was the fertilizing constituent most needed by the soil; for even when used alone it slightly improved the yield, and while nitrogen and potash [combined] gave only 4 bushels per acre, phosphoric acid and potash in (6) gave 7.33 bushels, and phosphoric acid and nitrogen in (7) gave 12 bushels.

Regarding the financial result, allowing $1 per bushel for the increased yield with fertilizers over the average yield of the unfertilized plats, there was a loss in every case except one (acid phosphate and muriate of potash). This loss amounted, with the various combinations, to from 18 cents to $13.41 per acre.

"The phosphoric acid either gave a profit or largely reduced the loss. Had the season been even an average one for wheat, it would, in judicious combinations with nitrogen, have given a fair profit."

2. *Varieties of wheat.*—Details of tests of 18 varieties are given in tabular form. In order to test the effect of change of climate, the seeds of Fultz wheat grown in Virginia and Illinois, were planted alongside of home-grown seed of the same variety, and seed of the Red May, from Illinois, were similarly compared with seed of the same sort from South Carolina. The yield in both cases was decidedly in favor of home-grown seed, a result "opposed to the opinion prevalent in some quarters, that change of seed is desirable."

Corn (pp. 162–217).—The experiments with corn include soil tests with fertilizers; special nitrogen, potash, and phosphoric acid experiments; tests of methods of applying fertilizers; of planting and of cultivation; tests of varieties; and rotations.

1. *Soil tests with fertilizers.*—These tests were carried on simultaneously at all three of the farms, the general plan being the same in all cases. The plats were each one-twentieth of an acre in size, and each test was duplicated. The nitrogen was furnished by nitrate of soda, the phosphoric acid by acid phosphate, and the potash by muriate of potash. These materials were used singly, two by two, and all three combined, and in quantities sufficient for a crop of 30 bushels of corn per acre. In order to determine whether the amounts of nitrogen, phosphoric acid, and potash, as calculated from the results of analysis, were the quantities actually required by the soil, the nitrogen when used in combination with phosphoric acid and potash was "reduced by 25 per cent, 50 per cent, and 75 per cent, and increased by 50 per cent and 100 per cent, the mineral constituents (phosphoric acid and potash) remaining the same. The phosphoric acid and potash were each, in like manner, reduced 50 per cent or increased 50 per cent and 100 per cent, the other two constituents remaining the same. And in still other tests all three were increased 50 per cent and 100 per cent to try the effects of the intensive system of manuring." From 6 to 10 plats were left unfertilized.

The land used at Spartanburg was in an impoverished condition. It was "a thin loam, high and gravelly, with clay subsoil. The plats were on the backbone of a slight ridge and very nearly level." At Columbia the soil was "a thin sand, almost destitute of vegetable matter, and worn out by years of improvident tillage under the tenant system. The surface of the land selected was level and smooth." The Darlington soil was "in wretched condition, very thin, out of tilth, and without vegetable matter. The field was very nearly level." The results are tabulated for each experiment, together with the average results of the three experiments. These results are regarded as "far from decisive."

> Not a single application paid for its cost. The season, however, was exceedingly unfavorable, cold and backward in the early spring, alternately wet and dry later on, and closing with disastrous floods, which seriously damaged the matured crop. In a more prosperous year the several applications would probably have given better returns.
>
> [Considering the three experiments together] the average yield of all the unfertilized plats was 10.49 bushels [per acre.] As compared with this, it appears, after allowing for the probable error, that potash, phosphoric acid, and nitrogen applied separately produced no effect. * * *
>
> Potash gave the poorest returns of all. Indeed it may be questioned whether its application was of any benefit to the crop. Its combination with phosphoric acid and with nitrogen gave an average not appreciably better than that of the unfertilized plats. Increasing it by 100 per cent [over the theoretical amount] and decreasing it by 50 per cent appears to have made little difference in the crop.
>
> The phosphoric acid was unmistakably required by the soil and beneficial to the crop. * * * In combination, especially with nitrogen, it added considerably to the yield of grain. * * *
>
> The nitrogen, like the phosphoric acid, was beneficial only in combination. Its effects were, perhaps, not quite so pronounced, * * *

Increasing the amounts of the fertilizers beyond a certain point gave no corresponding increase in the yield of grain. * * *

A careful study of the separate results of the tests at each farm and of their general averages, would seem to suggest that somewhere about the proper proportion of phosphoric acid, nitrogen, and potash would have been found in 250 pounds acid phosphate, 100 pounds nitrate of soda, and 50 pounds of muriate of potash.

2. *Special nitrogen experiments.*—In these experiments, which were similar in character to those with oats, described above, the effects of cotton seed (whole, ground, and crushed), stable manure, dried blood, and nitrate of soda were compared, muriate of potash and acid phosphate being in most cases used in connection with the other fertilizers. In each trial the plats were one-twentieth of an acre each in size. The amounts of fertilizer used and the average yields for the trials on the three farms were as follows:

Averages of Spartanburg, Columbia, and Darlington tests.

Plat.	Amount of fertilizer per acre.	Average of missing hills.	Average yield of corn per acre of duplicates, in grain.	
			Actual yield.	Corrected yield.
		Per cent.	*Bushels.*	*Bushels.*
1	Unfertilized	7.79	9.41	10.49
2	Muriate of potash ... 100 pounds Acid phosphate ... 120 pounds Nitrate of soda ... 240 pounds	7.18	13.72	14.87
3	Muriate of potash ... 100 pounds Acid phosphate ... 120 pounds Nitrate of soda ... 120 pounds	5.20	14.27	15.15
4	Muriate of potash ... 100 pounds Acid phosphate ... 120 pounds Dried blood ... 325 pounds	7.53	15.96	17.43
5	Muriate of potash ... 80 pounds Acid phosphate ... 20 pounds Cotton-seed meal ... 560 pounds	5.09	15.38	16.36
6	Muriate of potash ... 90 pounds Acid phosphate ... 65 pounds Cotton-seed meal ... 280 pounds	4.03	15.28	15.97
7	Cotton seed (whole) ... 1,560 pounds	4.43	15.43	16.19
8	Cotton seed (crushed) ... do	2.71	15.60	15.77
9	Muriate of potash ... 80 pounds Acid phosphate ... 50 pounds Cotton seed (ground) ... 780 pounds	2.44	14.32	14.61
10	Stable manure ... 8 tons	1.79	15.52	15.83
11	Stable manure ... 4 tons	3.58	14.31	14.92
12	Muriate of potash ... 65 pounds Acid phosphate ... 50 pounds Nitrate of soda ... 130 pounds Stable manure ... 2 tons	3.27	16.16	16.78

The averages do not materially change the results reached at the separate farms. All the applications show, as compared with the unfertilized plats, considerable gains, ranging from about 4 bushels to 7 bushels of grain per acre. On comparing the full amounts of nitrogen it will be noticed that nitrate of soda gave the smallest increase and dried blood the largest. * * *

Almost double the theoretical amounts of nitrogen, phosphoric acid, and potash (in 10) gave no better returns. Except in the case of nitrate of soda, reducing the amount of nitrogen slightly reduced the yield. * * *

Taking into account the cost of the nitrogen in the different fertilizing materials, the cotton-seed meal shows slightly the best results. The results of all the tests appear to indicate clearly only the following: First, that heavy doses of nitrogenous fertilizers can not be profitably used upon corn; and second, that cotton seed applied whole is equally as effective as when crushed or ground. To have weight, however, these conclusions must be confirmed by the results of the tests of four or five seasons.

3. *Special phosphoric acid experiments.*—Tests were made in duplicate on each of the three farms to compare the effects of like amounts of phosphoric acid in acid phosphate, "reduced phosphate" (made by mixing floats and acid phosphate in the proportion of 1 to 2), Thomas slag, and floats. These were applied with nitrate of soda 100 pounds, and muriate of potash 240 pounds per acre, and were used in quantities furnishing the full, and one-half the "theoretical" amounts of phosphoric acid required by the crop.

In the acid phosphate nearly all the phosphoric acid was in the soluble form; in the reduced phosphate, in the reverted or precipitated form; in the slag and floats, in the insoluble form. * * * Phosphoric acid in the acid phosphate cost about 5 cents per pound; in the reduced phosphate, about 4 cents per pound; in the basic slag, about 3½ cents per pound; and in floats, about 2½ cents per pound.

Twentieth-acre plats were used in each trial. The results of each test, and the average results of the three trials are tabulated. Considering the results of the three trials—

All the applications show small average gains as compared with the averages of the unfertilized plats. The increase ranged from 3 to 5 bushels per acre. On comparing the four phosphatic fertilizers, it will be seen that the difference between the averages of the acid phosphate, floats, and reduced phosphate, was less than 1 bushel of grain per acre. The average probable error was ±1.33 bushels per acre. The basic slag shows the smallest average of the four, the reduced phosphate the largest. Its average yield, however, exceeded that of the floats by only 0.48 bushels per acre. * * *

In the case of nitrate of soda and basic slag half the quantity of phosphoric acid was equally as efficacious as the full (theoretical) amount. But in the case of floats and reduced phosphate the full amount gave the largest average returns. * * *

One point of practical value brought out by the tests of this subsection is that the cheaper phosphatic manures appear to have been equally as effective as the more expensive ones.

4. *Special potash experiments.*—In this test, which was made on twentieth-acre plats at each of the three farms, the effects of like amounts of potash, in the forms of muriate and sulphate of potash and kainit were compared. The amounts of potash fertilizers used per acre on the different plats were as follows: muriate of potash, 100 pounds and 50 pounds; sulphate of potash, 130 pounds and 65 pounds; and kainit, 400 pounds and 200 pounds. The same amounts of acid phosphate (120 pounds per acre) and nitrate of soda (240 pounds) were used on each plat. From six to ten plats remained unmanured. The tabulated data show the average yield of the duplicate plats on each farm and the average yields for the three trials.

At Spartanburg the "potassic manures gave very unsatisfactory results; the sulphate was slightly the best of the three kinds tested, and half doses of potash answered just as well as the full."

At Columbia the potash fertilizers gave better returns than at Spartanburg, and the results seemed to indicate that they "were of some benefit to the crop; that the sulphate gave better results than the kainit, and the kainit in turn, as at Spartanburg, better results than the muriate; and that a reduction of 50 per cent in the potash, as compared with the full (theoretical) amount, did not injuriously affect the yield."

At Darlington, although the results were better than at Columbia "the differences were not as marked." The results seemed to indicate, however, that "sulphate was the most effective of the three kinds used, and that heavy applications of potash were not required. * * * For the first time muriate proved superior to the kainit."

The averages of all the tests made at the three farms "show, as compared with the averages of all the unfertilized plats, small average gains, as ranging from 4.38 to 7.01 bushels of corn per acre."

The potash as muriate costs 5 cents; as sulphate, 6 cents; and as kainit, 5¾ cents per pound.

On the soils of our three farms, potassic fertilizers, while of some benefit to the corn crop, were uniformly unprofitable. If these soils called for potash at all it was only in comparatively small amounts. The potash in the sulphate, notwithstanding its higher price, gave the best (pecuniary) returns.

The author calls attention once more to the "exceedingly unfavorable character of the season at all three farms."

5. *Modes of applying fertilizers to corn.*—"It appears to be the general belief in our section of the country that manures for hoed crops will give better results when applied in the drill or hill than when spread broadcast, more especially where only limited quantities are used." To get data on this question the following experiment was made at each of the three farms: A mixture containing "the full theoretical amounts of nitrogen, phosphoric acid [as acid phosphate], and potash [as muriate]," and another differing from the first only by a reduction of the nitrogen to one-half, were each applied broadcast and in the hill. Each separate test was duplicated, and the statement of results gives the average yield of the duplicate plats in each trial and the averages for the three trials. The results in all these trials indicated "no difference whatever in the results of the two methods of applying manures; that for moderate as well as heavy amounts of fertilizers the one was equally as effective as the other. But these tests are far from conclusive. They may give widely different results in a better season."

6. *Modes of planting corn.*—Using the same fertilizers (280 pounds cotton-seed meal, 65 pounds acid phosphate, and 90 pounds muriate of potash per acre) on each of the twentieth-acre plats at all three farms, the following variations were made in the method of planting on the various plats: The corn was "checked" 5 by 3 feet, 5 by 3½ feet, 5½ by 3 feet, 6 by 3 feet, and 5 by 4 feet, and drilled in rows 5 feet, 5½ feet, and 6 feet apart.

From the average yields of the duplicate plats in each trial and for the whole experiment "it is clear that [in this experiment] the different methods of planting gave practically the same results. The checked plats, however, were cultivated more economically than the drilled."

7. *Modes of cultivating corn.*—The objects of these experiments were to test "(1) the advantage of subsoiling the seed furrow before planting; (2) the comparative effects of deep and shallow cultivations; and (3) the value of thorough cultivation." The plats (one-twentieth acre each) all received the same fertilizers as in the preceding experiment on the methods of planting, and were all "well worked" except two in each test, which received "only half the number of workings."

From the results at the three farms "it is very clear that all four methods of treatment gave practically the same results. Such results should, however, be considered exceptional; for they are, in part at least, attributable to the poor condition of the soil and the very unfavorable character of the season. Thorough tillage will, in the long run, give the best returns."

8. *Varieties of corn.*—The results are given of duplicate tests of 21 varieties of corn.

9. *Corn in rotation.*—Four rotations were tried at all three farms, as follows:

> (1) Corn every year, unfertilized, peas sowed at last working; oats in the fall, to be turned under for corn in the spring, and the process repeated. * * *
>
> (2) Corn every year, with 600 pounds of marl per acre, and peas and oats as above. * * *
>
> (3) Corn every year, with 100 pounds muriate of potash and 120 pounds acid phosphate per acre, and peas and oats as above. * * *
>
> (4) Corn every year, with 90 pounds muriate of potash, 60 pounds acid phosphate, and 280 pounds cotton-seed meal, and peas and oats as above. * * *
>
> [For purposes of comparison unfertilized plats were planted with corn each year.]
>
> Other rotations were also tried at one or more of the farms.

The results for 1888 are tabulated.

"It appears from the results at all three farms that the corn was not injured by an accompanying crop of peas."

Cotton (pp. 218–291).—The experiments with cotton include tests of varieties; general fertilizer experiments; special nitrogen, phosphoric acid, and potash experiments; experiments with composts; modes of planting and topping; and rotations.

1. *Tests of varieties.*—Tabulated data are given for 12 varieties of cotton raised in 1888 at Spartanburg, 42 at Columbia, and 16 at Darlington; averages for 13 varieties tested at Darlington and Columbia, and for 8 varieties tested at all three farms; and averages for varieties tested for several years at the Columbia farm as follows: 37 varieties for 2 years, 25 varieties for 3 years, 14 varieties for 4 years, 13 varieties for 5 years, and 7 varieties for 6 years.

The averages for the 6 years' test of 7 varieties and the 5 years' test of 13 varieties are given as follows:

Averages for 1883, 1884, 1885, 1886, 1887, *and* 1888.

Variety.	Average yield of lint per acre of duplicates for each year.						Averages per acre for five or six years.			
	1883.	1884.	1885.	1886.	1887.	1888.	Lint.	Seed.	Lint and seed.	Lint.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Per cent.*
Peterkin	......	600	480	465	541	321	481	804	1,285	37.69
Dickson's Improved	368	547	465	404	471	259	419	938	1,357	31.00
Jones' Improved	401	560	446	327	518	265	419	961	1,380	30.50
Thomas	......	506	464	338	455	305	414	909	1,323	31.34
Duncan's Mammoth	402	477	387	432	388	343	405	869	1,274	31.57
Common	338	479	443	348	422	317	391	893	1,284	30.49
New Texas	......	506	434	298	452	306	399	892	1,291	30.91
Dickson's Cluster	378	465	477	323	453	273	395	906	1,301	30.40
Ozier's Silk	399	495	393	333	403	325	392	874	1,266	31.03
Cobweb	......	507	383	336	391	261	375	875	1,250	30.08
Hay's China	......	419	433	282	441	289	373	852	1,225	30,52
Crawford	......	366	374	305	488	331	372	834	1,206	30.91
Richardson's Improved	276	474	378	325	390	266	352	803	1,155	30.51

The results of tests covering a series of years carry with them great weight, and in all our tests of varieties care was taken to prevent any variety occupying the same two plats for two years in succession. This rotation of varieties on the same set of plats is for the purpose of eliminating, as far as possible, any differences in the soil. * * *

In this table the Peterkin maintains its superiority, giving an average of 62 pounds more lint per acre than the next best variety. In 1884, as well as in 1885, 1886, and 1887, it stood at the head of the list. There is very close agreement between the averages of several of the varieties.

2. *Soil tests with fertilizers.*—These were similar in general plan and object to the experiments on corn and wheat described above. They were carried out at each farm on twentieth-acre plats, the number of tests in the separate trials ranging from 25 to 30, all of which were in each case duplicated. The amount of nitrogen, phosphoric acid, and potash required for a crop of cotton yielding 300 pounds of lint per acre, as calculated by the results of analysis, was supplied by 330 pounds of nitrate of soda, 160 pounds of acid phosphate, and 100 pounds of muriate of potash. These materials were used singly, two by two, and all three together in the amounts stated above; and "for the purpose of determining the proper amounts of the three constituents" the full amount of phosphoric acid and potash used together was combined with, respectively, one-fourth, one-half, three-fourths, and the double (theoretical) amounts of nitrogen; the phosphoric acid and the potash in the complete mixture were likewise separately reduced to one-half and doubled; the ingredients of the complete mixture were doubled by twos; and finally all three of the ingredients were doubled, making a fertilizer with twice the theoretical amount of each ingredient. Marl (900 pounds per acre) was used alone, and marl (55 pounds, 110 pounds, and 220 pounds) and copperas (50 and 100 pounds) were each added to the complete (theoretical) fertilizer in separate tests. The season was unfavorable, as already mentioned.

The early spring was so cold and backward, and the consequent difficulty of securing good stands of cotton so great, and the later season so unfavorable and uncertain, that the action of the fertilizers was seriously interfered with and checked. The soils of our three farms were also sadly out of condition.

The yields for each test and the average yields for the three experiments are tabulated. The results on all the farms agreed quite closely in most respects. Considering the averages for all, "the unfertilized plats gave an average of 104 pounds of lint per acre. As compared with this—with proper allowance for error—the potash, nitrogen, and marl show no effect whatever. Phosphoric acid was of some little benefit to the crop. * * *

"The combination of full (theoretical) amounts of all three fertilizers gave very fair returns, the increase in yield amounting to about 250 per cent."

The addition of marl or of copperas to the complete fertilizer was in almost every case without apparent effect upon the yield. Doubling all three of the constituents of the complete fertilizer, and doubling the nitrogen in one case and the phosphoric acid and potash in another, the other constituents of the complete fertilizer being of the theoretical amount, "made no material differences in the yield." Reducing the nitrogen of the complete fertilizer by 25 or 50 per cent, or the phosphoric acid or potash by 50 per cent, "affected the yield very slightly, if at all"; but reducing the nitrogen by 75 per cent "was of serious injury to the crop."

[In general, then,] separate applications were without effect upon the crop, all three fertilizers being required by our soils. The standard or complete application gave very fair returns. Of the three constituents, potash appears to have been the least important and phosphoric acid equally as effective as nitrogen. Heavy applications were generally unproductive, and even in the assumed complete or standard combination the proportion of potash and nitrogen was perhaps too high. There is reason to believe that from 200 to 250 pounds of nitrate of soda, 130 to 160 pounds acid phosphate, and 50 to 75 pounds muriate of potash would have given equally as good returns.

The assumed full amounts of the three constituents in combination show an average profit of about $4.50 per acre; but, doubled, an average loss of about $5.75 per acre.

3. *Special nitrogen experiments.*—In these experiments tests were made of the comparative effects on cotton of nitrogen in the forms of (1) nitrate of soda, cotton-seed meal, and dried blood, when used with muriate of potash and acid phosphate, and when used in the full and half theoretical amounts; (2) cotton seed, whole, ground, or crushed, when used with muriate of potash (100 pounds per acre); (3) ground cotton seed combined with muriate of potash and acid phosphate; (4) stable manure, 6 and 12 tons per acre; and (5) stable manure, 3 tons, and nitrate of soda, 160 pounds, combined, when used with muriate of potash, 50 pounds, and acid phosphate, 70 pounds, per acre. Each application contained "the full or normal amounts" of phosphoric acid and potash, and the full or half amount of nitrogen, except in the case

of stable manure, 12 tons per acre, "containing double the normal amounts of the three constituents."

The plats were, as in previous experiments, one-twentieth of an acre each in size, and 14 duplicate plats were used in the experiment at each farm.

The average yields of the duplicate plats in each trial and the averages for the three trials are tabulated. The results at the different farms vary too widely to allow of generalizations, except in a few instances. The results of all three trials indicate that the full amounts of dried blood, stable manure, nitrate of soda, and cotton-seed meal were about equally efficacious. At two of the farms 12 tons of stable manure gave a larger yield than any other fertilizer; at the third this amount of manure was not as effective. Cotton-seed meal gave better results than cotton seed, either whole, ground, or crushed.

In other words, 745 pounds of the meal was more than equal, as a nitrogenous fertilizer, to 2,080 pounds of the seed, a proportion of 1 to 2.79. In the oil mills a ton or 2,000 pounds of seed gives about 700 pounds of meal, besides oil and some waste products. * * *

[The average results of these experiments, as well as of those reported above,] show that the full or theoretical amount of nitrogen was excessive, and that half the quantity would probably give equally as good results. They strengthen the opinion expressed above, that from 200 to 250 pounds nitrate of soda or its equivalent would answer in place of the 330 pounds of the formula.

4. *Special phosphoric acid experiments.*—A comparison of "the relative values of available and insoluble forms" of phosphoric acid. The experiments were the same as the special phosphoric acid experiments with corn (p. 150), except that the amounts of fertilizer used were slightly changed to correspond with the calculated amounts for cotton previously given. As before stated, nearly all the phosphoric acid of the acid phosphate was "in the soluble form," that of the reduced phosphate "in the reverted form," and that of the slag and floats "in the insoluble form."

The acid phosphate shows the best average, as well as the best results, at each farm. The reduced phosphate stands second in the list, floats third, and the slag last.

At two of the farms the full amount of acid phosphate gave a considerably larger yield than the half amount, and half amounts of the other forms of phosphoric acid gave about as good results as full amounts; but at Darlington the half dressings of both acid phosphate and slag "proved as effective as the full," and the yields were less with half amounts of floats or reduced phosphate than with full amounts.

The average increase afforded by the phosphatic fertilizers, as compared with the average yield of the unfertilized plats, varied from about 50 to 250 per cent.

The results of the experiments of this subsection appear to indicate that the value of phosphoric acid, for the soils experimented with, was dependent upon the solubility of the forms employed; the readily soluble (in the acid phosphate) being the most effective, the insoluble (in the floats and slag) the least, the slowly soluble (in the reduced phosphate) standing midway between them. They also support the conclusion that the theoretical amount of phosphoric acid used was not excessive.

5. *Special potash experiments.*—These experiments, in which the effects of potash in the form of muriate, sulphate, and kainit were compared, were the same in general plan as the special potash experiments with corn (p. 150). The (full and half) amounts of potash fertilizers were the same as in those experiments, but acid phosphate and nitrate of soda were used so as to furnish the theoretical amounts of nitrogen and phosphoric acid for the cotton. The results are tabulated as for previous experiments.

It is very clear from these averages that the potash was equally effective at all three farms, showing an increase of from 100 to 140 pounds of lint per acre. Hence the question of the relative cost of the potassic fertilizers becomes an important one. The muriate would be preferred as being somewhat the cheapest of the three. * * *
The half amounts [of potash] gave in every case as good returns as the full.

6. *Composts on cotton.*—This is a comparison at Columbia of eight composts for cotton with each other, with the "standard" (theoretical) mixture of muriate of potash, acid phosphate, and nitrate of soda, with a mixture of half the amounts of these and 3 tons of stable manure per acre, and with no fertilizer. The composts were as follows:

Ingredients per ton of compost.

	Acid phosphate.	Floats.	Kainit.	Cotton seed.	Stable manure.	Cost per ton.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	
Furman's compost No. 1	333⅓		166⅔	750	750	$8.41
Georgia and Alabama compost No. 2	500			750	750	8.50
North Carolina compost No. 3	800		200	600	400	10.40
South Carolina compost No. 4	750		350	600	300	10.87
No. 5		750	350	600	300	9.75
No. 6	750		350	900		12.37
No. 7		750	350	900		11.25
No. 8				1,000	1,000	7.00

In none of the composts were the three constituents present in the estimated or theoretical proportions. The nearest approach was in No. 8, which contained, roughly speaking, about one-half the required amounts of nitrogen and phosphoric acid and one-fourth the required amount of potash. No. 7 contained about seven times the theoretical amount of phosphoric acid.

The composts were all applied at the rate of 1,600 pounds per acre. The average yields of cotton on the duplicate twentieth-acre plats are tabulated.

As was to be expected from its composition, No. 6 gave slightly the best results. No. 7, which differed from No. 6 in having floats instead of acid phosphate, gave almost the same average. So did No. 5, with a mixture of cotton seed and stable manure. On comparing No. 5 with No. 4 it will be seen that the floats gave better results than the acid phosphate. Nos. 5, 6, and 7 gave almost the same returns as the mixture of fertilizers and stable manure and the stable manure alone, and somewhat better results than the standard application. No. 2 gave rather better results than No. 1 and No. 3. No. 8, a much cheaper compost, gave as good results as any one of the three. Accepting the figures as they stand in the table, the profit (+) or loss (−) per acre of the several applications may be given as follows:

Theoretical mixture of fertilizers, +61 cents; half of theoretical and 3 tons of stable manure, +$4.43; stable manure alone, +$4.65; compost No. 1, +68 cents;

No. 2, + \$3.74; No. 3, — \$1.40; No. 4, + 38 cents; No. 5, + \$7.44; No. 6, + \$6.26; No. 7, + \$4.68, and No. 8, + \$3.17.

It is evident that compost No. 5 gave the best and compost No. 6 the next best results. In a similar series of tests carried on for several years at this farm, but on a very different soil, No. 5 gave nearly similar results, showing continued superiority.

7. *Modes of applying fertilizers on cotton.*—This is a comparison at each of the farms of the methods of applying fertilizers in the hill and broadcast, the same kinds and amounts of fertilizer being applied both ways.

The applications were made at the time the cotton was planted. The required (theoretical) amounts of nitrogen, phosphoric acid, and potash were furnished by cotton-seed meal, acid phosphate, and muriate of potash. Full and half amounts of nitrogen were tested.

The results for each trial and the averages for the three trials are tabulated. The results "warrant the conclusion that last year the broadcast method of applying fertilizers was, at our three farms, just as effective as the other method of dropping them in the hill."

8. *Modes of planting cotton.*—A comparison of the methods of planting cotton in checks and in drills and at different distances.

All the plats at each farm received the same application of same fertilizers, furnishing the full (theoretical) amounts of phosphoric acid and potash and half the required amount of nitrogen.

Cotton was grown in checks 3½ by 2½ feet, 3½ by 3 feet, 3½ by 3½ feet, 4 by 2½ feet, 4 by 3 feet, 4 by 3½ feet, 4 by 4 feet, 4½ by 2½ feet, 4½ by 3 feet, 4½ by 3½ feet, and 4½ by 4 feet, and in drills 3, 3½, 4, and 4½ feet apart. The average results for the three separate trials indicate the following:

In the checked plats the average difference between close planting [3½ by 3 feet] and thin planting [4½ by 4 feet] was only 14 pounds of lint per acre. In the drilled the difference between the 3½-foot rows and 4½-foot rows was only 9 pounds of lint per acre. The differences between the intermediate distances in both modes of planting were almost as slight. Again, between [checks 3½ by 3½ feet and drills 3½ feet apart] the difference was only 17 pounds of lint per acre; between [checks 4 by 3 feet and drills 4 feet apart], only 25 pounds; between [checks 4½ by 3 feet and drills 4½ feet apart], only 9 pounds. The close agreement between the average results of the several tests is remarkable. * * * The checked plats were, however, cultivated somewhat more economically than the drilled.

Attention is again called to the unfavorable season, which may have influenced the general results.

9. *Topping cotton.*—Two tests in which the cotton on a twentieth-acre plat was topped and that on another, which received exactly the same treatment otherwise, was not topped, indicated that "the topping was of no benefit to the crop."

10. *Cotton in rotation.*—Eleven systems in which cotton occurred each year, were tried at each farm. In these the cotton was followed the same year by a crop of oats or peas, or by these crops alternately, the latter being plowed under; the cotton seed was returned to the soil; in addition to the seed a green crop of oats was plowed under, and fertilizers and the green manuring were variously combined. The results

for 1888 are tabulated. As "it is of course too early to expect results," the present report being merely a report of progress, the details of the experiments need not be given.

The following points are cited:

> It is abundantly clear from the results of the several tests, as well as from their averages, that planting peas at the last working did not injure the cotton.
>
> It was particularly noticed at the Columbia farm that the oats to be plowed under this spring were much heavier where peas were planted last year between the cotton rows. On many of the plats at the three farms the oat crop furnished a large amount of vegetable matter to be turned under.

WEST VIRGINIA.

West Virginia Agricultural Experiment Station.

Department of West Virginia University.

Location, Morgantown. Director, J. A. Myers, Ph. D.

FIRST ANNUAL REPORT, 1888.

REPORT OF DIRECTOR (pp. 5-38).—This is for the fiscal year ending June 30, 1888, and contains a brief account of the organization and first work of the Station, including statements regarding an attempt to interest the farmers of the State in the establishment of creameries. The following bulletins were issued in 1888: No. 1, Organization and Work of the Station, J. A. Myers, Ph. D.; No. 2, History, Properties, Sources of Ingredients, Mode of Application, and Uses of Commercial Fertilizers, A. R. Whitehill, M. A.; No. 3, Birds of West Virginia, W. D. Doan, M. D.

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